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ALUMINUM WELDING

OUT-OF-POSITION WELDING OF 5000 SERIES ALUMINUM ALLOYS USING PULSE GMAW POWER SOURCES

FINAL REPORT
JANUARY 1984

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VOLUME I

TABLE OF CONTENTS

1. Foreword
2. Acknowledgements
3. Table of Contents
4. Introduction
5. Process Description
6. Pulse GMAW Power Sources & Accessories
7. Base Materials: 5000 Series Aluminum Alloy Sheet & Plates
8. Filler Materials: 5000 Series Aluminum Alloy Filler Wires
9. Weld Joint Designs
10. Shielding Gases & Weld Characteristics
11. Material Preparation
12. Weld Joint Fit-Up
13. Weld Tests

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FOREWARD

This report primarily describes the weld test work conducted during the development of welding procedure qualification data, welding techniques and welding procedure specification relative to full penetration, one-side, out-of-position, manual pulsed gas metal arc butt welding of 5000 series aluminum alloy sheets and plates for marine fabrication.

This project was conducted with the use of basic "off-the-shelf" welding power sources (less than $5,000], feeders, guns and accessories currently available to all U.S. Shipyards.

Our literature survey indicated that substantial information covering gas metal arc welding (GMAW) of aluminum alloy is available. However, very little information appeared available on manual one-side, full weld penetration gas metal arc butt welding of 5000 series aluminum alloy sheets and plates in all welding positions with the use of either pulse or short-arc welding modes on the pulse arc equipment. The short-circuit mode has not been applied commonly to aluminum welding since it had originally been developed for steel in CO_2 gases.

No high speed oscilloscope nor high speed motion pictures were taken to interpret the physical meaning of GMM in the pulse spray transfer or IN the "pulsed short-circuiting" arc welding modes. All testing was conducted on a one-on-one basis, i.e. the welder vs. attainment of full penetration, one-side, out-of-position manual gas metal arc welding of marine aluminum alloy sheet and plate.

It is anticipated that some of the results and techniques developed might be implemented as an improved cost-effective approach to hull, superstructure, sheet metal and piping fabrication. It is also anticipated that fabricators of surface effect ships, hydrofoils and crew boats may find applications of some information developed.

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TABLE OF CONTENTS

1. Foreword
2. Acknowledgements
3. Table of Contents
4. Introduction
5. Process Description
6. Pulse GMAW Power Sources & Accessories
7. Base Materials: 5000 Series Aluminum Alloy Sheet & Plates
8. Filler Materials: 5000 Series Aluminum Alloy Filler Wires
9. Weld Joint Designs
10. Shielding Gases & Weld Characteristics
11• Material Preparation
12. Weld Joint Fit-Up
1.3. Weld Tests
14. chipping
15. Welding Techniques
16. Repair Welding
17. Preheat, Interpass, Post-Heat Temperatures
18. Mechanical Properties
19. Weld Machine Settings
20, Welding Procedure Specification: Guide
21. General Conclusions & Recommendations
22. References

INTRODUCTION

Substantial gas metal arc welding (GMAW) developmental work on aluminum and aluminum alloys has been conducted by the Navy, Aluminum Manufacturers, and the Shipbuilding Industry itself. However, very little work has been conducted to develop out-of-position, full penetration, one-side, manual gas metal arc butt welding of aluminum alloys with the use of pulse spray or “pulse short-arc” modes. This phase of manual gas metal arc welding of aluminum alloy sheet and plates has not been fully developed nor fully utilized by the shipbuilding industry.

The pulse spray and also the short circuiting arc welding mode is a variation of the gas metal arc welding process. The pulsed arc welding power source usually provides a dual-level welding current and provides substantially improved weld deposition control for out-of-position welding. Both the background and the pulsed peak welding current can be controlled separately or electronically so that the actual average welding current is precise. In the past, out-of-position GMAW in the spray mode could not be used effectively because the molten weld puddle was so hot that the puddle sagged or rolled because of gravity. With the use of the new pulsed GMAW power sources, however, the use of the background level provides sufficient cooling of the weld puddle to allow out-of-position welding. Radiographic inspection quality levels were anticipated to be superior to conventional GMAW welds, i.e. per MIL-STD-0900-003-9000; “Radiographic Standards For Production and Repair Welds.”

The primary purpose of the project was to determine and establish manual pulsed gas metal arc welding techniques and also welding machine settings for the one-sided fusion welding of strain hardened 5000 series marine aluminum alloy sheets and plates in the 1/16 inch to 1/2 inch thickness range. The primary objective was to make manual butt welds in the horizontal, vertical-up and overhead welding positions and produce full penetration root weld pass deposits with the minimal use of strong backs and without the use of either metallic or ceramic back-up bars. The welding test piece parts to be welded were gas metal arc GMAW tack welded only and were fiXtured with minimal restraints.

The primary objective of this project was to produce out-of-position, full penetration, manual gas metal arc GMA. butt welds from one-side and yet meet weld quality levels similar to those attained with the use of gas tungsten arc welding GTAW. It was felt that substantial (30%-50%] cost savings could be attained as a result of overall increased productivity and minimum distortion weldments realized through out-of-position, one-side, full penetration gas metal arc welding.

The advantages of pulsed spray welding were primarily higher deposition rates when welding out-of-position. The other advantages are as follows:

Rework, repairs, or straightening costs would be minimized because full penetration welds usually eliminate repairs on lack-of-fusion type defects.
Weld quality levels similar to gas tungsten arc welding can be attained.
Weld distortion is held to a minimum because of low heat input and good depth/width ratio weld cross sectional configuration.
Less weld repairs will be encountered.
Easier and greater working ranges for out-of-position welding will be appreciated.

However, in spite of the many advantages that the pulse arc process provides, many welding people have avoided it because of two major factors; 1] higher cost of the welding machines/system and; 2) the complexity in setting the machine up to the proper pulse voltage peak vs. background voltage balance in addition to taking care of the other necessary machine variables.

Also, in the past many welders and welding engineers have shied away from using the conventional GMAW short-circuiting arc process when welding aluminum alloy sheet/plate materials in the out-of-position mode. This was because the droplet transfers were uncontrollable due to improper balance of slope, inductance, electromagnetic pinch force, pulse amplitude, pulse duration, pulse frequency and voltage feedback control systems.

It is anticipated that the results of this report may encourage aluminum and aluminum alloy fabricators to consider the advantages of manual pulsed arc welding of aluminum and aluminum alloy sheet and plate materials by utilizing the out-of-position, full penetration, one-side welding technique.

For clarity's sake, various discussions, comments and often conclusions and recommendations follow a specific topic because of the numerous welding variables involved in this study.

PROCESS DESCRIPTION

In order to define pulsed arc welding, it appears necessary to define gas metal arc welding GMAW which is more commonly known as MIG welding or metal inert gas welding.

GAS METAL ARC WELDING: GMAW

The American Welding Society (AWS) defines gas metal arc welding GMAW as follows:

> “An arc welding process wherein coalescence is produced by heating with an arc between a continuous filler metal (consumable) electrode and the work. Shielding is obtained from an externally supplied gas."

The basic GMAW system usually consists of a power source, wire feeder with controls, welding gun (torch) and shielding gas system and accessories. See Figure 1.

The standard (non-pulsedl gas metal arc welding of aluminum alloys in the spray transfer mode is used primarily for welding plate materials (.188 inch thick and greater) and sheet materials (.125 inch thick and greater). When the conventional spray transfer mode is used the welding is usually done in the flat position. This is because the higher current levels make the weld puddle very fluid. In the GMAW spray transfer mode the fine metal droplets are pinched off the wire and and propelled across the arc gap to the work as illustrated in Figure 2.

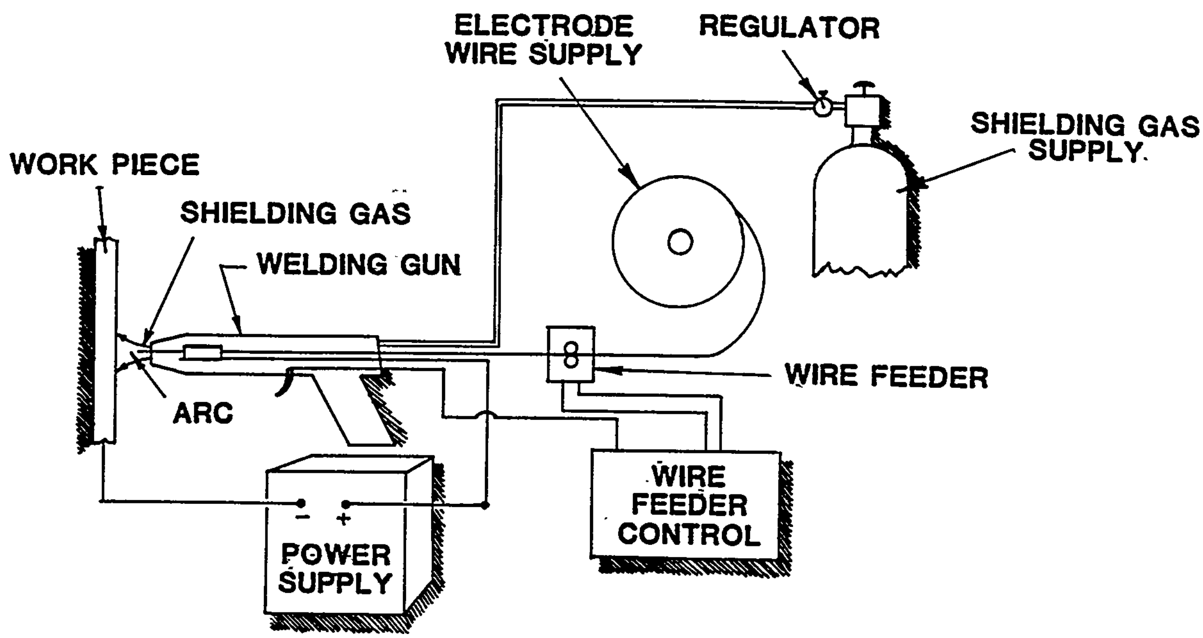


FIGURE 1

GAS METAL ARC WELDING EQUIPMENT

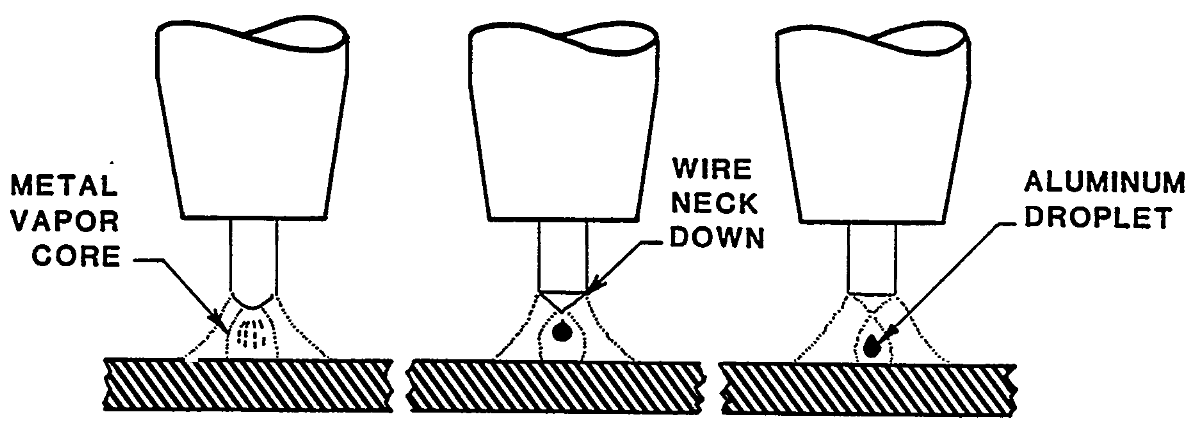


FIGURE 2

GMAW: SPRAY ARC

PULSED GAS METAL ARC WELDING

Pulsed arc welding is a variation of the gas metal arc welding GMAW process. With pulsed GMAW, the welding power source(s) provides a dual level welding current and provides substantiaily improved weld deposition control especially for out-of-position welding applications. Both the background and the pulsed peak welding currents can be controlled separately so that the actual average welding current may be set more precisely than with the use of conventional GMAW power sources.

In pulsed spray gas metal arc welding the current is varied between a high (peak) and low (background) value. The low level of current is below the non-pulsing transition current while the high on the peak current level is well into the spray arc region, i.e. if the upper current were continuous, it would provide spray transfer and if the lower current were continuous it would produce globular transfer. Metal is transferred to the work during the peak current levels. Figure 3 illustrates the pulsed GMAW welding current cycle pattern. In the spring of 1983, most of the "off-the-shelf" pulsed arc power sources manufactured in the United states appeared to use pulse in either 60 or 120 pulses per second. However, one manufacturer has recently begun manufacturing a pulse GMAW power source covering an approximate range of 50-250 pulses per second.

When using argon or argon rich mixtures or 75% helium/25% argon gas shielding with the pulsed GMAW process, a spray transfer occurs above the transition current value for a given electrode and diameter involved. As the current density at the electrode is increased, the end of the filler wire (electrode] will form into a droplet because of the "pinch effect". Droplets of molten aluminum appear much smaller than wire diameter and are propelled by the arc force. See Figure 4.

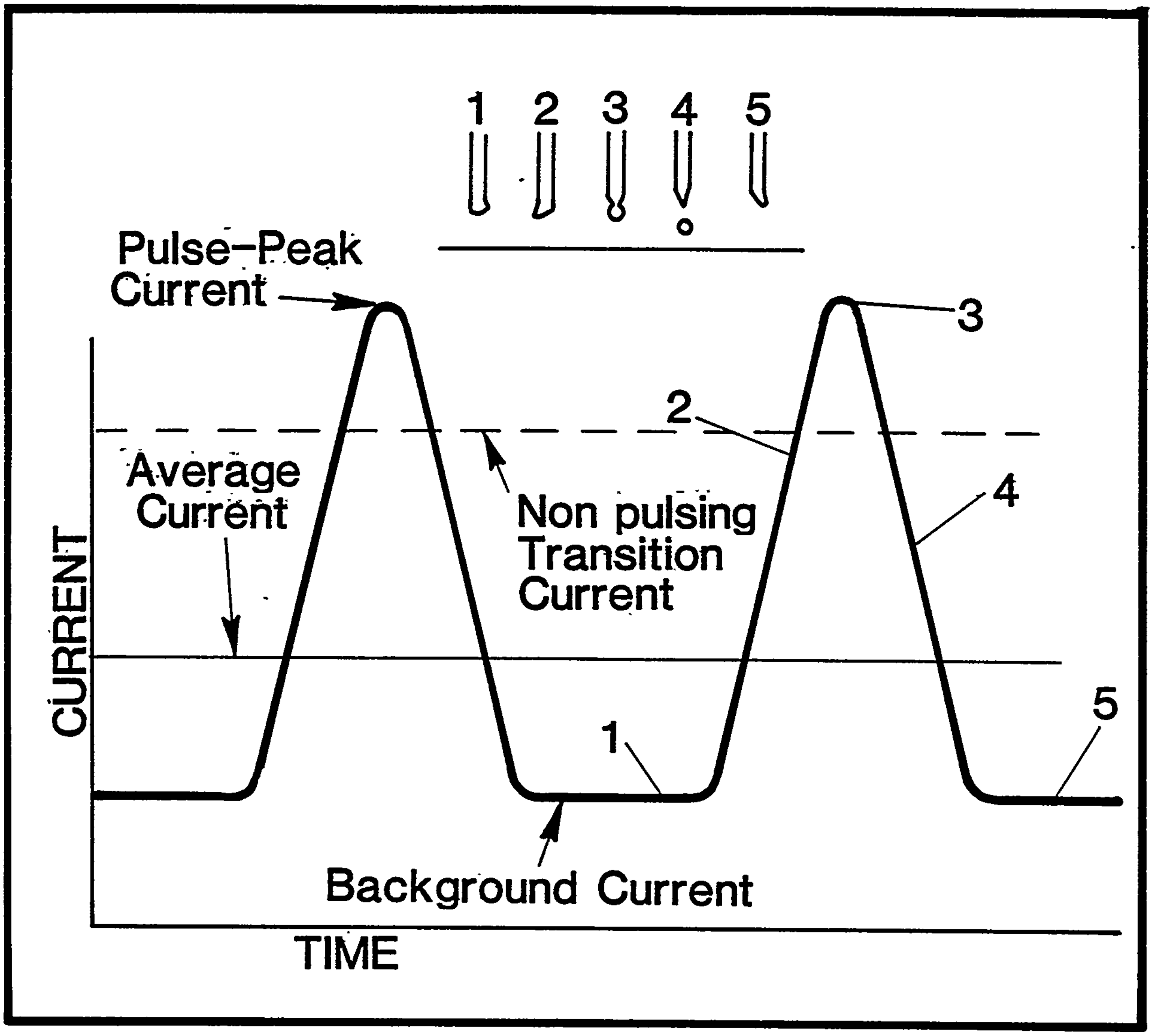


FIGURE 3

TYPICAL PULSE GMAW CURRENT CYCLE PATTERN

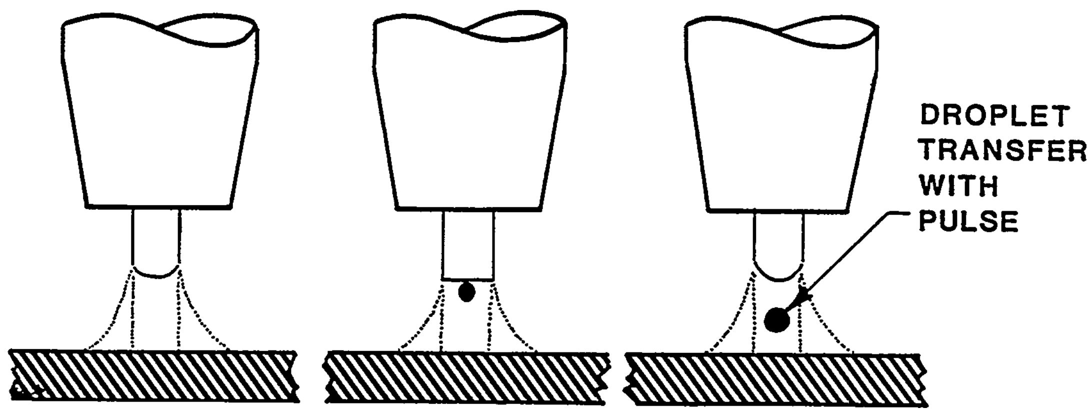


FIGURE 4

PULSED GMAW: PULSED SPRAY

The three methods of metal transfer in pulsed gas metal arc welding are pulsed spray, globular and short-circuiting transfer.

PULSED SPRAY TRANSFER

As discussed earlier in the text, the pulsed arc GMAW process utilizes a peak and background current levels producing an average current value. The resultant current level is a lower average current heat level than when a continuous conventional spray transfer mode is used. The tip of the filler wire melts and the molten metal drops transfer in a spray during each current peak pulse when most of the energy input as utilized for melting the base material and the filler wire material. Usually, there is not sufficient time for globular transfer to occur and more than adequate time at temperature for spray transfer to melt the electrode. Adjustment of both the pulse peak and amperage and background is usually available unless these functions are electronically pre-programmed. The arc is maintained by the background current. The pulse peak current must be set high enough so that the metal droplets are propelled through the arc at a high velocity for one-side, full penetration, manual pulsed gas metal arc welding in the out-of-position mode.

The droplet size tends to stay the same but the rate of drops transferred increases with frequency, i.e. from 50-250 pulses per second (pps). Most power sources pulse only in 60 or 120 pps. The cooler arc is attained by using the lower pulse, i.e. 50 pps or 60 pps depending on the power source.

With the use of the conventional continuous (standard GMAW) spray arc, it was difficult for the average "new hire welders to make out-of-position welds. The work usually had to be positioned for down hand (flat) welding. On the other hand, with the use of the pulse current a lower heat input spray arc transfer may be used for welding in the vertical-up, horizontal and overhead welding positions.

The pulsed gas metal arc process permits the use of larger diameter wires with the use of push wire feeders. A much lower average current may be used with 3/64 inch diameter wires than is possible for the conventional GMAW process. Larger diameter filler wires generally provide better wire feeding capabilities in addition to better weld deposit quality, i.e. .030 inch diameter filler wires have lower columnar strength and requires a pull gun.

GLOBULAR ARC TRANSFER

When pulsed gas metal arc welding power sources are used, the globular arc transfer usually occurs below the pulse peak current corresponding to the conventional non-pulsing transition current level. This globular transfer range covers the minimum current density which will melt the filler wire up to the point where higher peak amperage produces a pulsed spray transfer.

With the use of conventional gas metal arc welding power sources, the globular transfer usually is avoided because the arc cone covers a much larger area and causes shallow weld penetration, lack of fusion, and irregular metal deposition and certainly is not suitable for out-of-position welding.

“PULSED SHORT-CIRCUITING ARC"

As described in the previous paragraphs, the conventional globular arc transfer does not lend itself to one-side, out-of-position full penetration manual gas metal arc welding. See Figure 5. The Airco PA-350 power source in the “short-circuiting mode” does not appear to be the same as the conventional short-arc mode. When the globules short-circuit by coming in contact with the puddle and electrode at the same time the arc force is so strong that the molten globules have good arc stability and provide good full penetration welds with good depth to width ratio.

Unfortunately, no high speed motion pictures at 3,000 frames per second were taken and also the use of a high speed oscilloscope was not available.

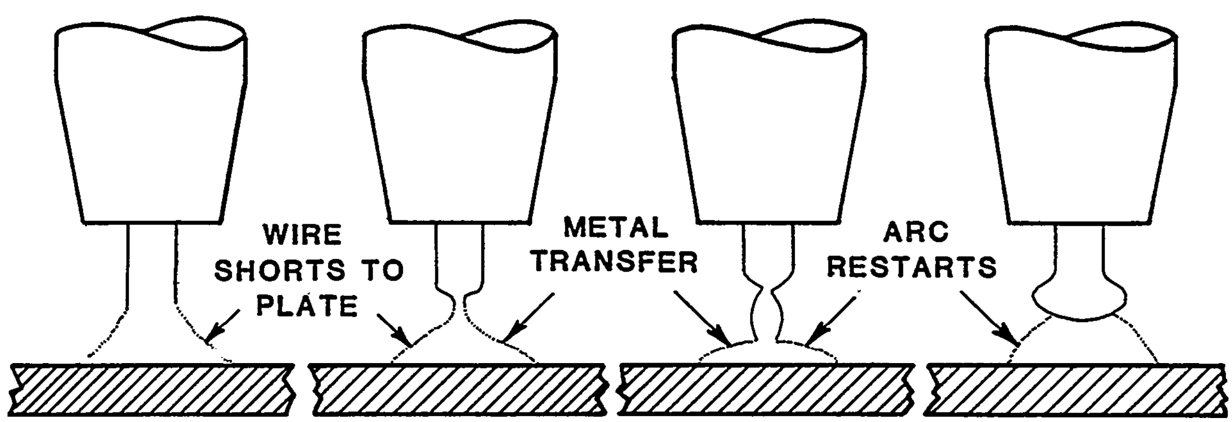


FIGURE 5

STANDARD GMAW: SHORT CIRCUITING

The advantages of the pulse and “pulse short-circuiting” modes of gas metal arc welding are as follows:

Permits the welder to make a one-side, full penetration, out-of-position weld using the manual GMAW process.

Provides cooler arc and less distortion.

Minimizes weld spatter and undercutting.

Permits the out-of-position welding of thin sheet materials, e.g. .063 inch thicknesses of aluminum alloy sheet.

Permits spray transfer welding at average currents below those normally possible.

Provides improved arc control for out-of-position welding and more effective welding of thin gauge material, with all the advantages of spray transfer, i.e. minimizes excessive weld puddle fluidity.

Permits use of larger diameter electrode wires which cost less, feed easier and also have a lower surface-to-volume ratio which reduces the possibility of weld porosity and, in some cases, weld cracking.

Provides precision control of current to assure bead shape and root penetration approaching GTAW quality.

PULSED ARC GMAW POWER SOURCES

When this project was originally proposed in the Spring of 1982, only one production model "off-the-shelf type" pulsed GMAW power source appeared to be available in the United States. This was the Airco PA-3A. Since that point in time, however, American manufacturers have begun producing pulsed GMAW power sources, primarily because of the interest in utilizing the advantages offered by low heat input for joining quench and tempered steels such as HY-80/HY-100 for submarine and other marine applications.

The original scope of this program stipulated the determination of the "best" pulsed GMAW power source for welding aluminum. However, during the course of this program it was determined that the preferred power source should be left as a choice of individual shipyard Welding Engineers for their particular application. As this program progressed, it became more evident that the establishment of the "best" power source would be extremely subjective and difficult. It would result in the unfair comparison of dissimilar GMAW power sources, and wire feeder systems, i.e. not suitable for comparison. Furthermore, many of the equipment manufacturers are working on their next generation pulse power sources.

The welding power source designed for pulsed gas metal arc welding is usually a constant voltage type. Pulsed GMAW power sources usually have added pulse features which significantly improve arc stability, weld puddle control, weld arc column shape, and also provide a wider and controllable spray arc transfer working range.

The program covered four types of pulsed arc welding power sources. These are as follows:

1. Airco PA-3A
2. Airco PA-350
3. Gilliland CV 600 FI-PA
4. Miller Pulstar

Each pulsed GMAW power source has its own special merits and areas of applications. They all appeared to operate according to the same basic principles of a GMAW power source. However, substantial variations in welding power source specifications appear in areas such as process modes, pulse rates (pulse per second), pulse source(s), and pulse control method, etc.

During the welder familiarization period with the four candidate pulse arc welding power sources, it was surprising to discover that the short-circuiting arc mode needed to be included as another alternative approach to attain our primary program objective, i.e. full weld penetration from one-side, out-of-position manual GMNT. As described in the previous paragraph under Process Description, the “new” short arc mode does not appear to be the conventional short-circuiting arc transfer with which most of us are familiar.

The four pulse GMAW power sources are described in the following paragraphs.

* * * * * * *

AIRCO PA-3A

The Airco PA-3A for pulsed arc welding has two transformer-rectifiers connected in parallel. A three phase full wave rectifier SCR provides the background current and controls the arc length. A single phase rectifier provides the pulsing current.

The dual power source is used only in the pulse spray mode: 60 or 120 pps.

When using the Airco PA-3A, the welder is confronted with the following items listed below:

Power on/off toggle switch.
DC ammeter (0-500 amperes).
DC voltmeter (0-100 volts).
Three position voltage toggle switch (peak, average, background).
Pulse rate toggle (120 pps vs. 60 pps].
Pulse peak, pulse width potentiometer knob.
Background pulse switch extra 1ow vs. normal.

EXTRA LOW	NORMAL
Toggle Switch #l = 8.5A ys. Off +	Toggle Switch - Raise ys. Lower
Toggle Stitch #2 = 8.5A vs. Off+	
Toggle Switch #3 = 17.OA vs. off	

See Figure 6.

The volt-ampere tune, the metal transfer sequence and the schematic for the Airco PA-3A are shown in Figure 7, 8, and 9 respectively. The Airco PA-3A welding power source, AHF-NP pull feeder, and AH35-C2 gun is shown in Figure 10.

The following procedures are used to set up and calibrate the Airco PA-3A pulsed GMA welding machines.

1. Visual check of mechanical and electrical components.

2. Hook up primary power and check main contactor for proper operation.
3. Check voltages on transformer secondaries for proper output.
4. Check phasing on transformer secondaries.
5. Calibrate firing circuit printed circuit board for minimum and maximum pulsed width.
6. Check background voltage.
7. Check meter accuracy against oscilloscope.
8. Load test output for maximum voltage - amperage.
9. Set up with wire feeder and weld test.

NOTE :

The above check list is reduced to items 2, 6 and 9 only in order for a user to set-up.

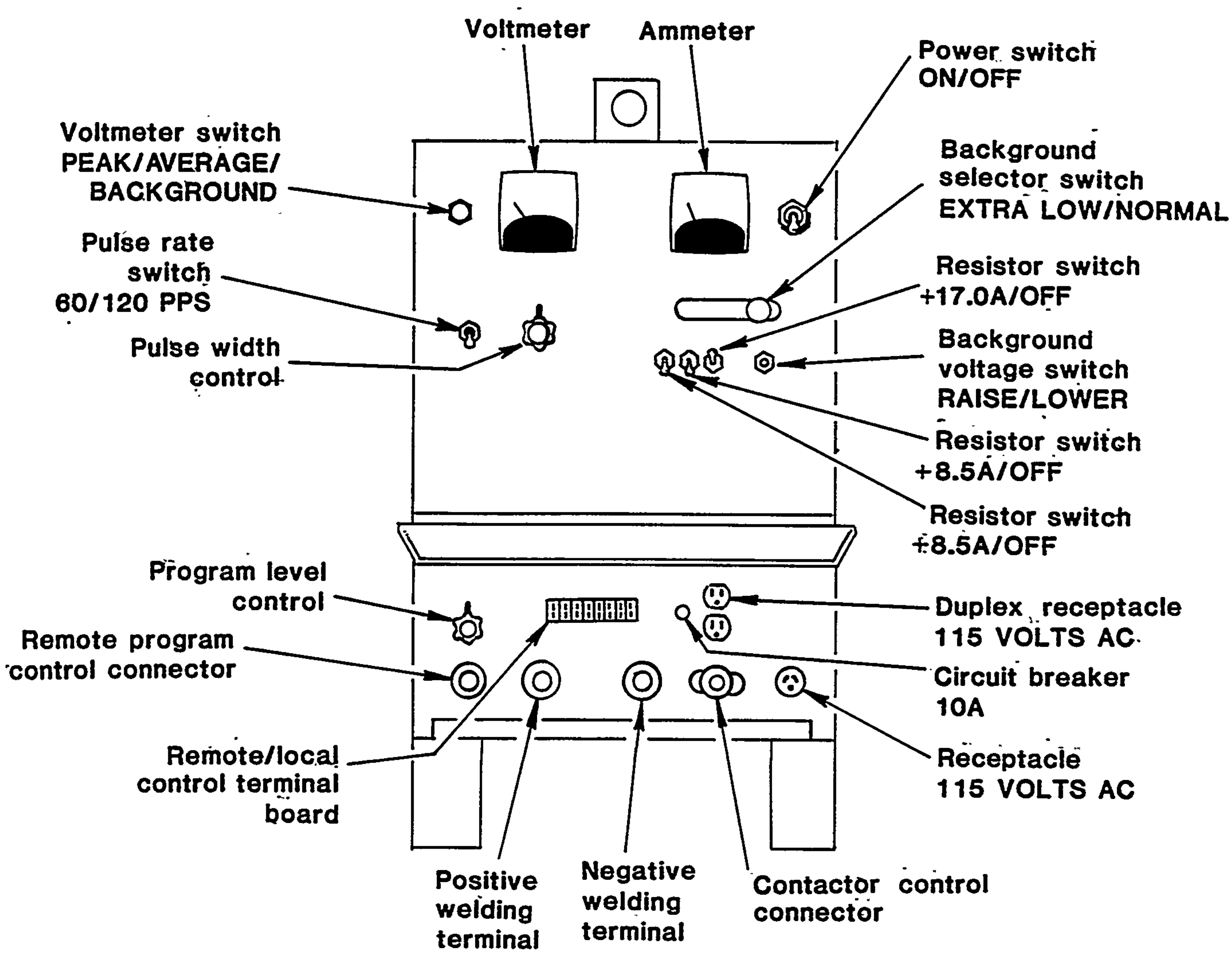
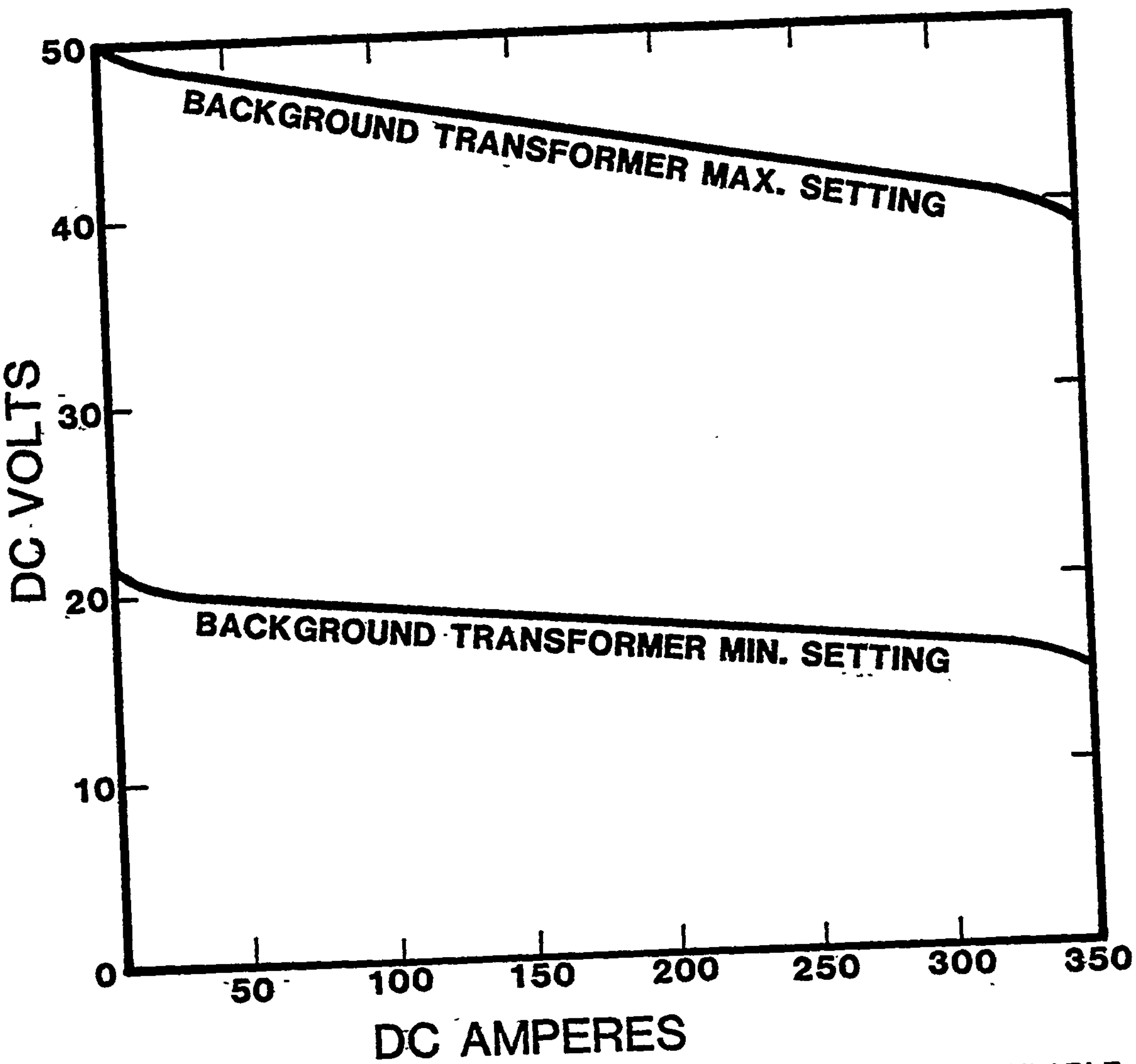


FIGURE 6

AIRCO MODEL PA-3A PULSED ARC WELDING MACHINE



NOTE: A LOWER RANGE FOR BACKGROUND VOLTAGES IS AVAILABLE BY A SECONDARY CONNECTION INSIDE THE PA-3A.

FIGURE 7

AIRCO PA-3A: VOLT-AMPERE CURVE

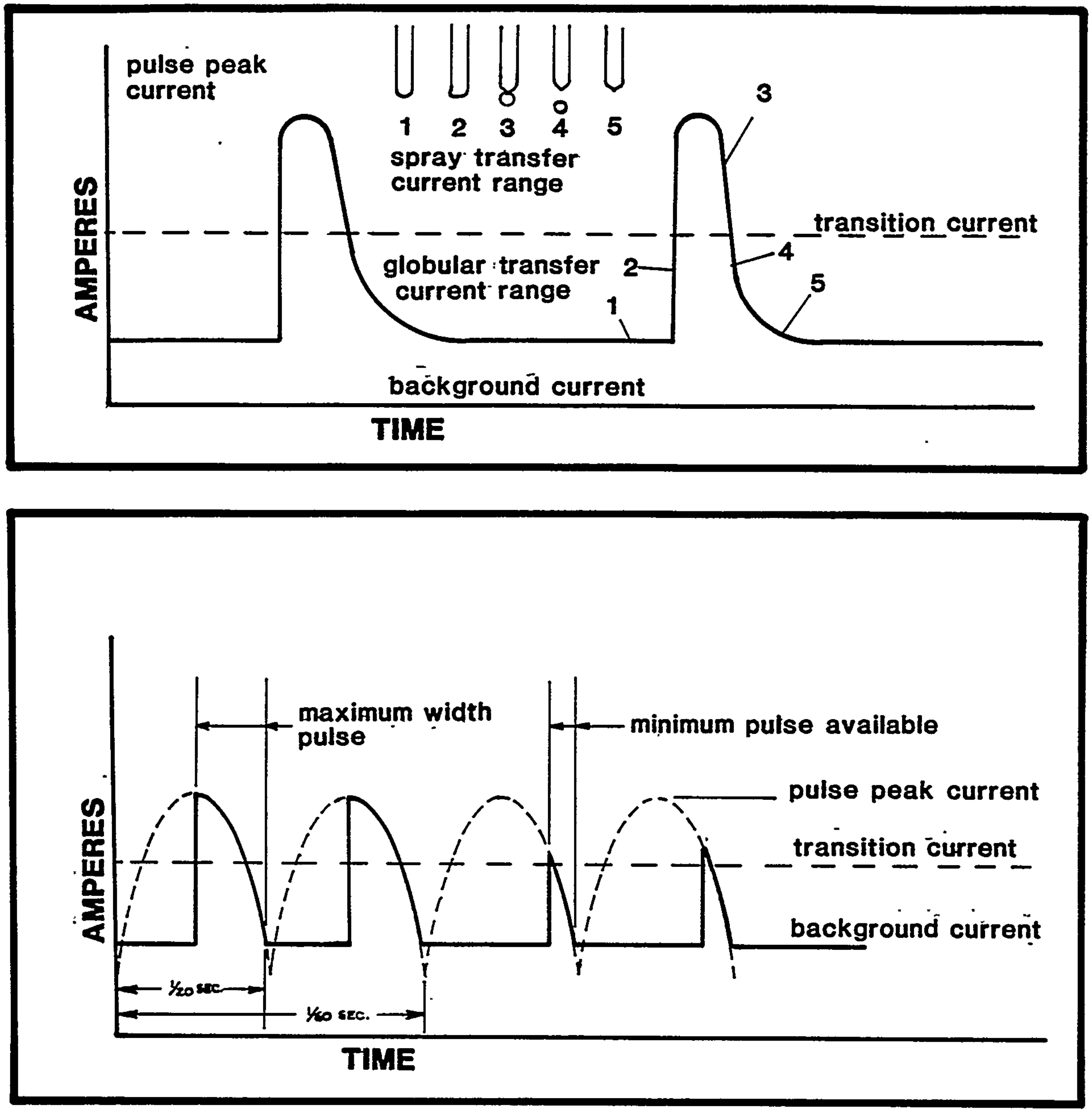
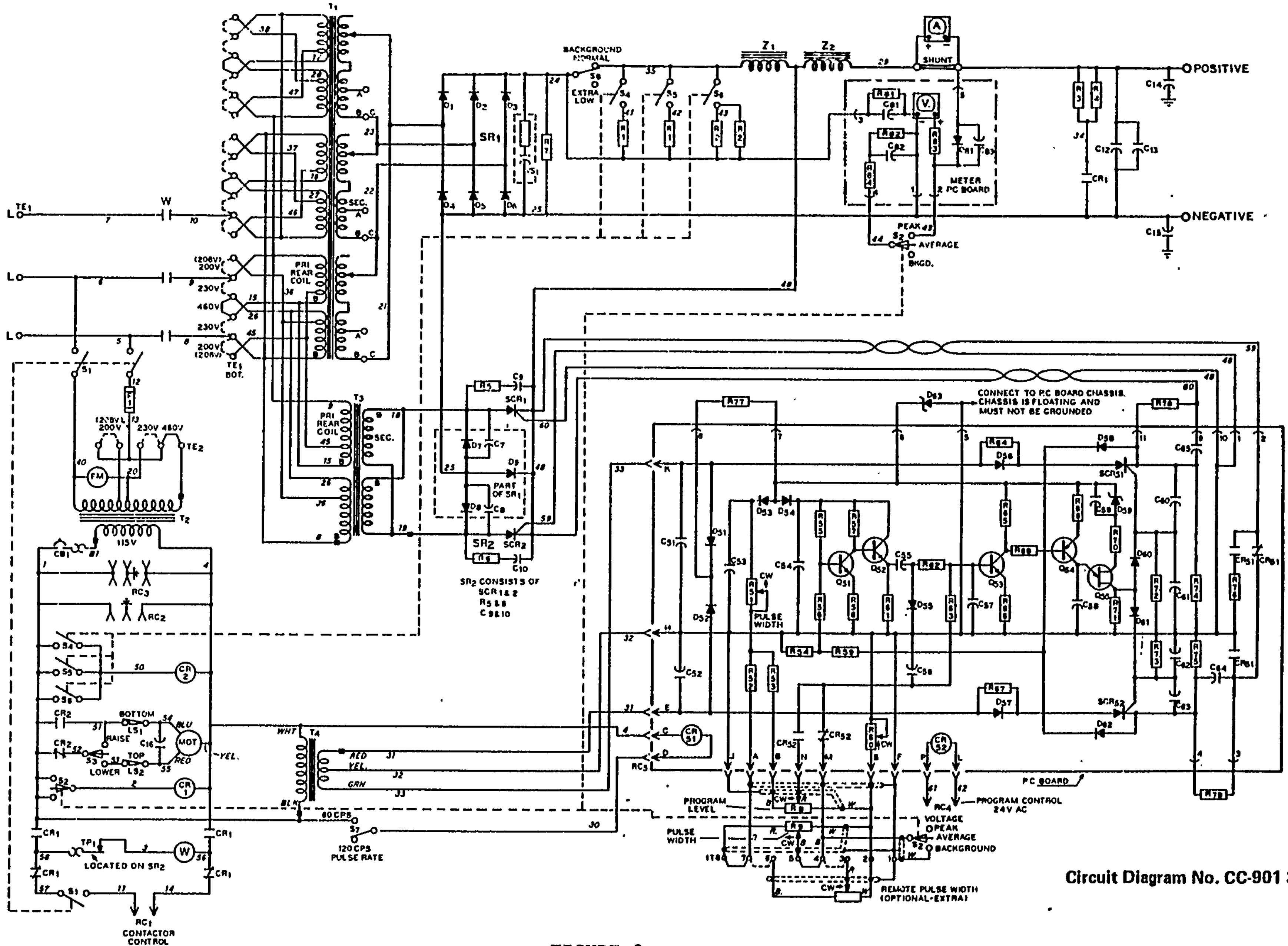


FIGURE 8

AIRCO PA-3A; METAL TRANSFER SEQUENCE



Circuit Diagram No. CC-901 313-1A

FIGURE 9

AIRCO PA-3A

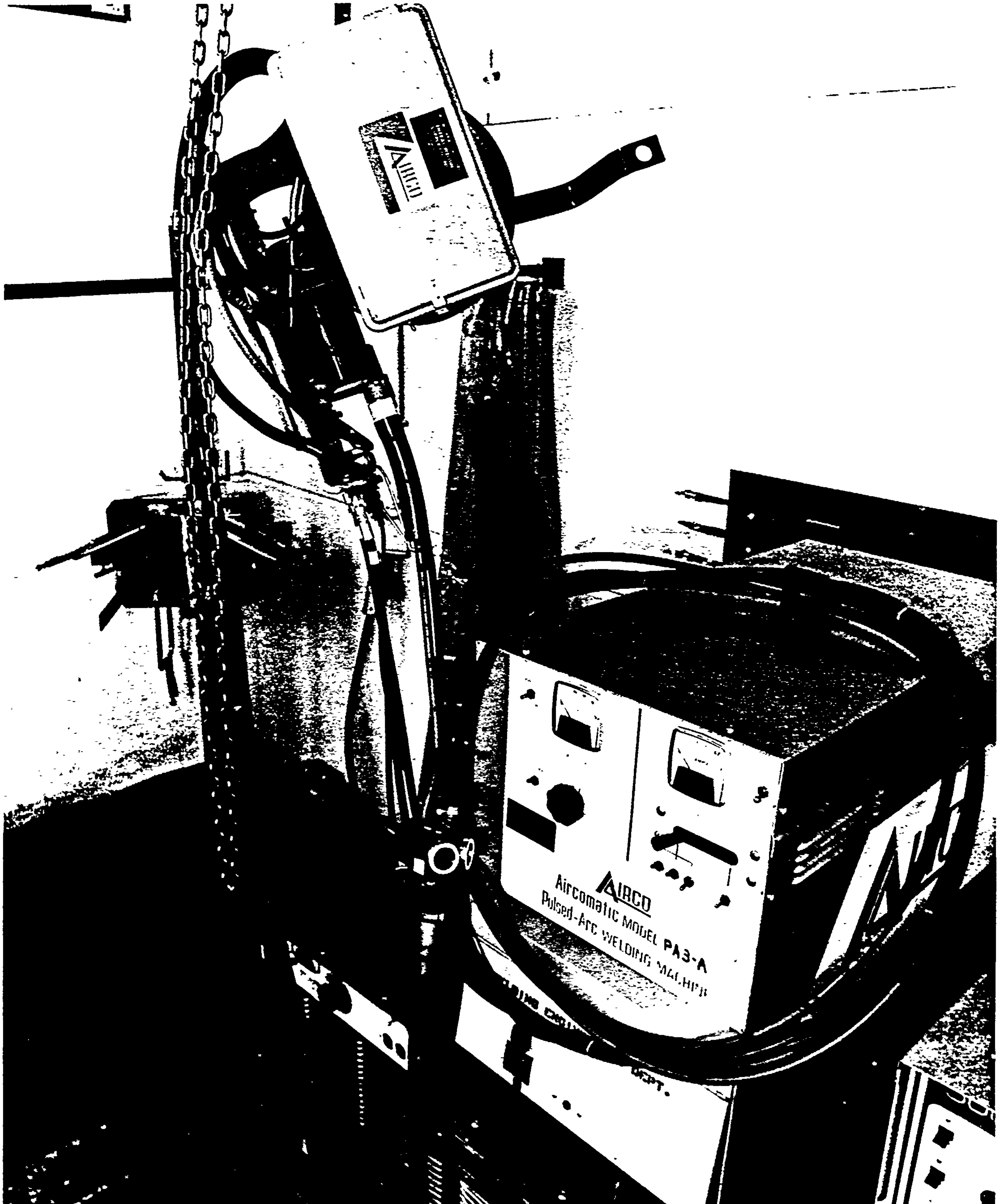


FIGURE 10
AIRCO PA-3A PULSE ARC WELDING POWER SOURCE, AHF-NP PULL FEEDER, AH35-C2 GUN

AIRCO PULSE ARC 350 WELDING SYSTEM

The Airco PA-350 Welding System consists of a constant voltage solid state welding power source, System 1 wire feeder, Aircomatic GMAW gun and remote control pendant.

The lightweight feeder is a dual drive roll unit, double insulated and totally enclosed for added operator and component protection. All wire feeder control circuitry is housed in the power source environmental compartment.

Standard features include slow run-in start, wire jog switch, built-in three-roll wire straightener, calibrated adjustable drive roll pressure and fixed pre- and post-flow timers. Wire speed is automatically controlled over a range of 40-800 inches per minute (i.p.m.) with standard hard and soft wire sizes .035 through l/16 inch

The remote control pendant contains the synergic control potentiometer, arc length fine adjustment potentiometer, a manual wire feed speed adjust-
* potentiometer and a manual/automatic mode switch.

The welding gun included with the system is a new Aircomatic air-cooled gun. It is rated at 400 amps. $C0_2$ and is of single conduit design with heavy duty slip-on nozzle and quick disconnect fitting.

The welding meters and controls of the Airco PA-350 power source are listed as follows:

- DC ammeter CO-500 amperes).
- DC voltmeter CO-50 volts).
- Pulse process toggle switch (Up = $C0_2$)
  (down = Argon/$C0_2$), and (middle= Pulse Mode).
- Crater toggle switch (up = pulse
  (down - Argon/$C0_2$).

- Push buttons

#1 CRATER FILL	#2 WIRE DIAMETER	#3 MATERIAL	#4 GAS
in = on	in - .035°	in = SS	in = purge
out = off	out = .045″	out - Ms	out = weld

NOTE :

SS = Stainless Steel
MS = Mild Steel

- Crater current potentiometer. (applies only when #1 is pushed in).

  Crater current (0-10)

  Crater voltage (0-10]

  Background (0-10)

- Power on/off switch.

Important features of this welding system are as follows:

"Electronic" wave shaping circuit in the $C0_2$ or Argon/$C0_2$ mode.

Pulsed spray and dip transfer process capabilities.

Single knob synergic control.

Crater fill.

Pre/post flow timers.

Solid state contactor.

Line voltage compensation.

Thermal overload protection and indicator light.

Environmentally protected cabinet design.

400 amp. gun (10 ft.).

Remote control pendant.

Voltmeter and ammeter.

115 VAC auxiliary power with 5 amp. circuit breaker fuse (0.5 kva) and dual receptacle.

Energy saving circuit.

Wire feeder:

- lightweight, totally enclosed.
- wire sizes: .035 and .045 inch hard standard and 3/64 and 1/16 inch soft, optional 12 and 14 inch spools standard and 8 inch and 60 lbs. chipboard cores optional.

Slow run-in.

Wire job switch.

Built-in wire straightener.

Wire tip conditioning (stub burn off).

The Pulse Arc 350 system is a multi-purpose unit designed for pulsed spray transfer/"pulsed short-circuiting arc” welding.

Single control knob automatically establishes average current (wire feed speed) and average arc voltage for an optimum welding condition based on a given material, tire diameter and shielding gas. This system eliminates the need to individually set peak voltage/current, pulse frequency and background voltage current. The synergic characteristic of this control makes these selections automatically. The system consists of a power source, a totally-enclosed wire feeder, remote control pendant and a lightweight 400 amp. GMAW gun.

The power source output is controlled by a solid state control and power transistors which also compensate for line power input voltage fluctuations.

This system allows out-of-position welding with aluminum wires and is ideally suited for thin gauge material allowing increased welding rates without an increase in heat input resulting in subsequent weldment wax-page. In addition, excellent “pulse short-circuiting” welding maybe performed at outputs as low as 40 amperes, i.e. 3/64 inch diameter wire.

The standard system comes equipped to weld with .035 and .045 inch mild steel and stainless steel wires. With appropriate option, the system can weld with aluminum in 3/64 inch and 1/16 inch diameter wires.

The PA-350/System 1 feeder allows the use of one-to-two 1-2) size larger diameter electrodes. For example, 3/64 inch diameter aluminum alloy filler wires can be used in lieu of .035 inch or .030 inch diameters when welding a specific base material thickness such as .063 inch material thickness. This feature alone improves productivity because the use of larger diameter wire improves weld quality, offers better wire feeding characteristics and also reduces equipment down time.

The Airco PA-350 Welding System specification covering the power source, wire feeder, gun and physical data is illustrated in Figure 11. Also, a duty cycle chart, volt-ampere curve for pulsed spray arc, volt-ampere curve for short-circuiting mode and block diagram are illustrated in Figures 12, 13, 14, and 15. Also, background control settings and sequence of operations with and without crater fill are shown in Figures 16 and 17.

POWER SOURCE	PULSE SPRAY PROCESS	DIP-TRANSFER PROCESS
Rated Output	350 Amps @ 36 Volts	280 Amps @ 27.5 Volts
Duty Cycle	60%	60%
Primary Input	3 Phase	3 Phase
volts	230/460,60 Hz	230/460,60 Hz
Primary Input Amperes	50/25	40/20
KW-Input	18	14.4
KVA-Input	20	16
Maximum Open Circuit Volts	78	78
Auxiliary Power (KVA)	0.5 @ 115 VAC	0.5 @ 115 VAC

WIRE FEEDER	
Feed Type	Push
Wire Sizes:	
Hard	0.035 inch (0.889 mm) Standard
	0.045 inch (1.14 mm) Standard
soft	3/64 inch (1.19 mm)
	1/16 inch (1.58 mm)
Feed Rate	40 to 800 ipm (1.02 to 20.5 mpm)
Spool Size	12 and 14 inch standard
	8 inch and 60 lb. Chipboard cores optional

GUN	
Cooling	Air
Gooseneck Angle	45°
Rated 60% Duty Cycle	
(DCRP) Amps: CO_2	400
Argon	360
Conduit Length	10 feet (3.04 m)

PHYSICAL	
Net Weight System	420 lbs. (189 kg)
Shipping Weight System	445 lbs. (201 kg)
Height (Power Source)	27-1/4 inches (69 cm)
Width (Power Source)	19-1/4 inches (49 cm)
Depth (Power Source)	39 inches (99 cm)
Height (Wire Feeder)	12-1/2 inches (32 cm)
Width (Wire Feeder)	8 inches (20 cm)
Depth (Wire Feeder)	19 inches (48 cm)

DESCRIPTION
Pulse Arc 350 Power Source/Feeder/Gun/Remote Control Pendant 230/460, 3 phase, 60 Hz

FIGURE 11

AIRCO PA-350 WELDING SYSTEM
SPECIFICATION

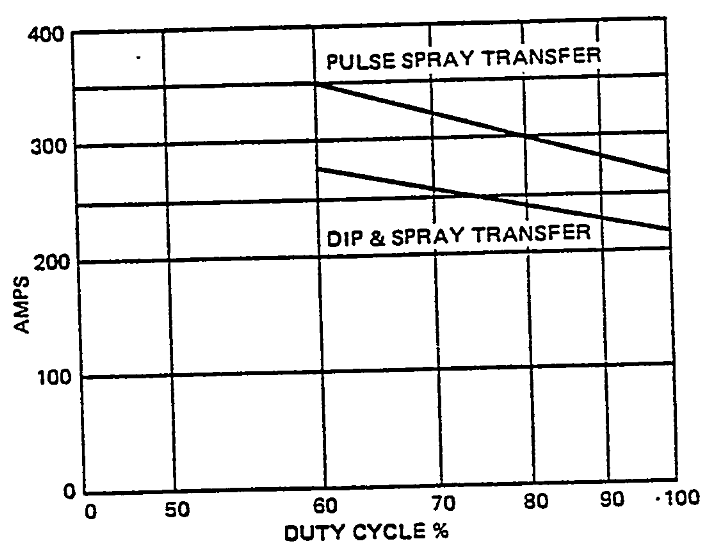


FIGURE 12

DUTY CYCLE CHART

AIRCO PA 350

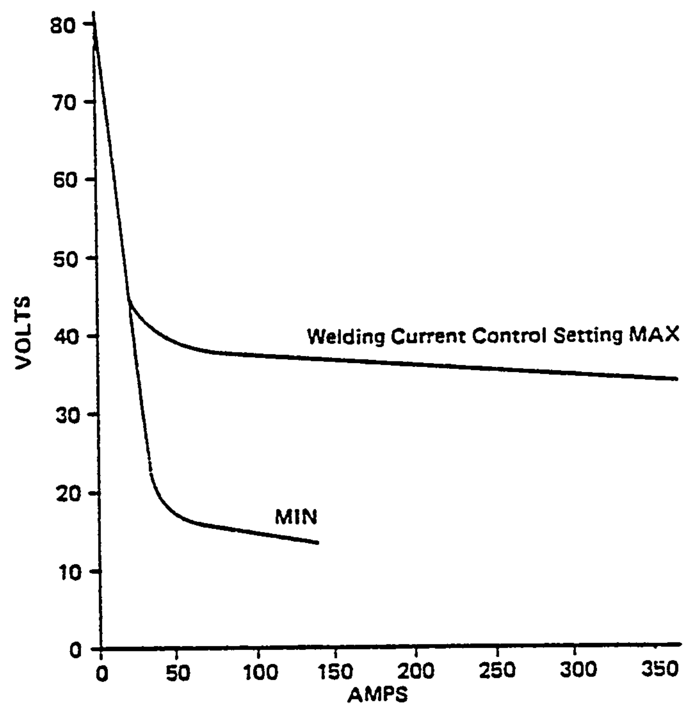


FIGURE 13

VOLT - AMPERE CURVE

PULSE SPRAY ARC

AIRCO PA 350

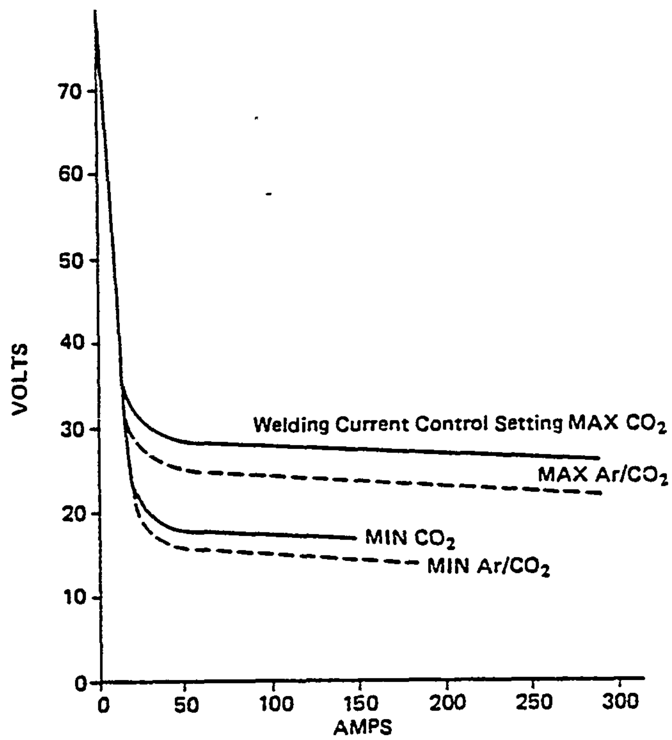


FIGURE 14

VOLT - AMPERE CURVE

SHORT CIRCUITING ARC

AIRCO PA 350

ASTM/AWS 5.10 Classification	Si, percent	Fe, percent	Cu, percent	Mn, percent	Mg, percent	Cr, percent	Ni, percent	Zn, percent	Ti, percent	Percent other[a] elements, each b	total	Al,[b] percent
ER 5356	0.25	0.40	0.10	0.05-0.20	4.5-5.5	0.05-0.20	-	0.10	0.06-0.20	0.05	0.15	Remainde
ER 5556	0.25	0.40	0.10	0.50-1.0	4.7-5.5	0.05-0.20	-	0.25	0.05-0.20	0.05	0.15	Remainde

NOTES :

1. Single values shown are maximum percentages, except where a minimum is specified.

2. Analysis shall be made for the elements for which specific limits are shown. If, however, the presence of other elements is suspected or indicated in the course of routine analysis, further analysis shall be made to determine that these other elements are not in excess of the limits specified for “other elements.”

   a. Beryllium shall not exceed 0.0008 percent.

   b. The aluminum content is the difference between 100.00 percent and the sum of all other metallic elements present in amounts of 0.010 percent or more each, expressed to the second decimal before determining the sum.

FIGURE 25

ASTM/AWS 5.10 SPECIFICATION FOR ALUMINUM AND ALUMINUM ALLOY BARE WELDING RODS & ELECTRODES

WELDING FILLER WIRE CHEMICAL COMPOSITION REQUIREMENTS [1,2]

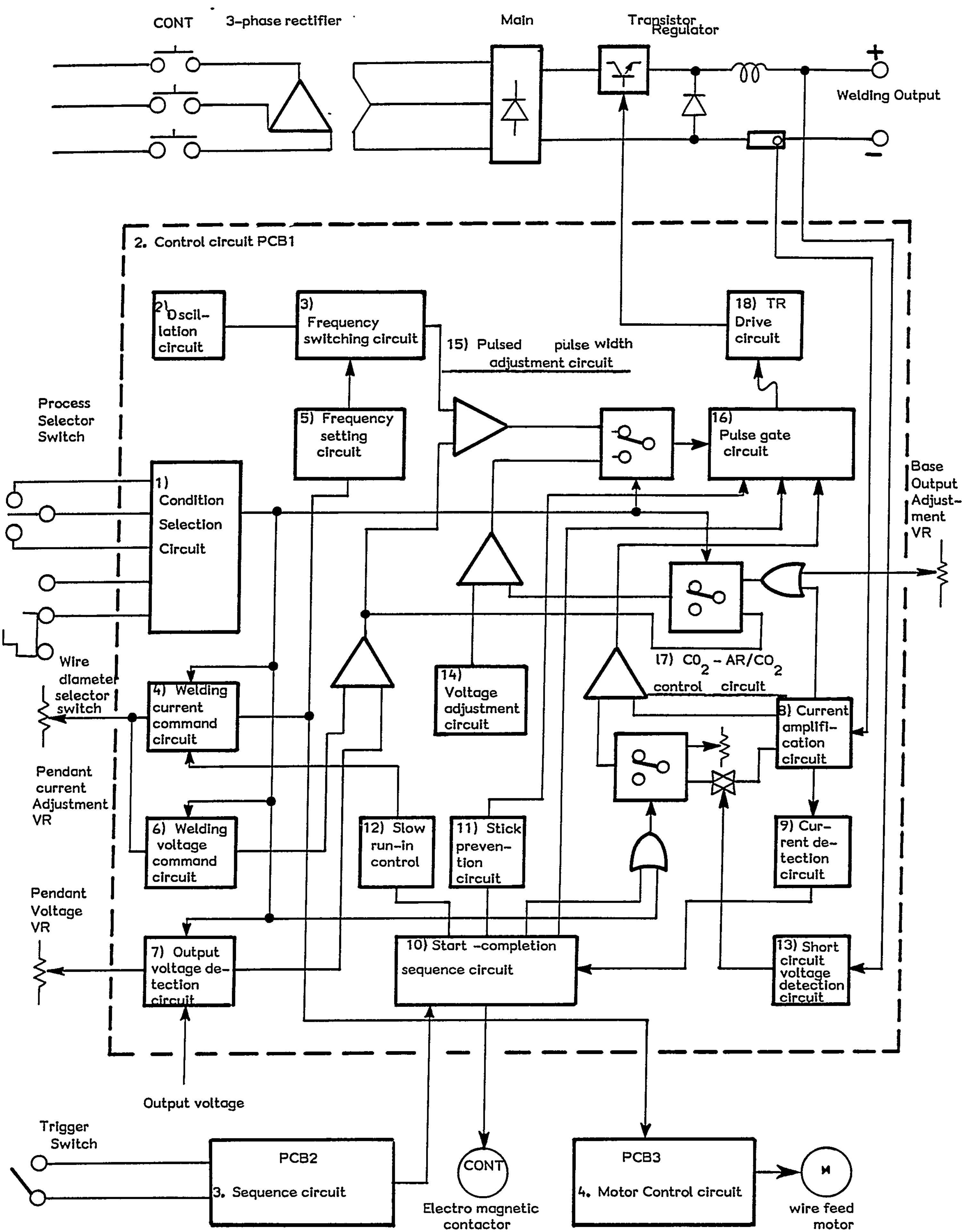

CONT
3-phase rectifier
Main
Transistor Regulator
Welding Output
+
−
2. Control circuit PCB1
2) Oscil-lation circuit
3) Frequency switching circuit
15) Pulsed pulse width adjustment circuit
18) TR Drive circuit
Process Selector Switch
5) Frequency setting circuit
16) Pulse gate circuit
Base Output Adjust-ment VR
1) Condition Selection Circuit
Wire diameter selector switch
4) Welding current command circuit
14) Voltage adjustment circuit
17) CO_2 - AR/CO_2 control circuit
8) Current amplifi-cation circuit
Pendant current Adjustment VR
6) Welding voltage command circuit
12) Slow run-in control
11) Stick preven-tion circuit
9) Cur-rent de-tection circuit
Pendant Voltage VR
7) Output voltage de-tection circuit
10) Start -completion sequence circuit
13) Short circuit voltage detection circuit
Output voltage
Trigger Switch
PCB2
3. Sequence circuit
CONT
Electro magnetic contactor
PCB3
4. Motor Control circuit
wire feed motor

FIGURE 15

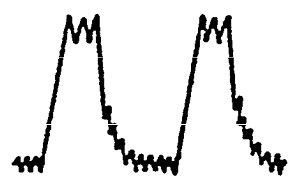
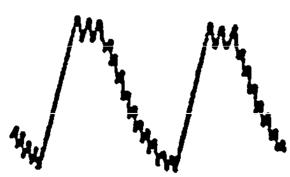
BACKGROUND CONTROL SETTING	CURRENT WAVEFORM	REMARKS
0-2		Full spray power, crisp arc, narrow arc Pulse mode transfer characteristics fully displayed.
2-7		Softer arc, less concentrated (< 150A) Use < 10% CO_2 for good transfer
7-10		Soft arc, wide column spray transfer difficult below 200A. Use < 10% CO_2 for good transfer.

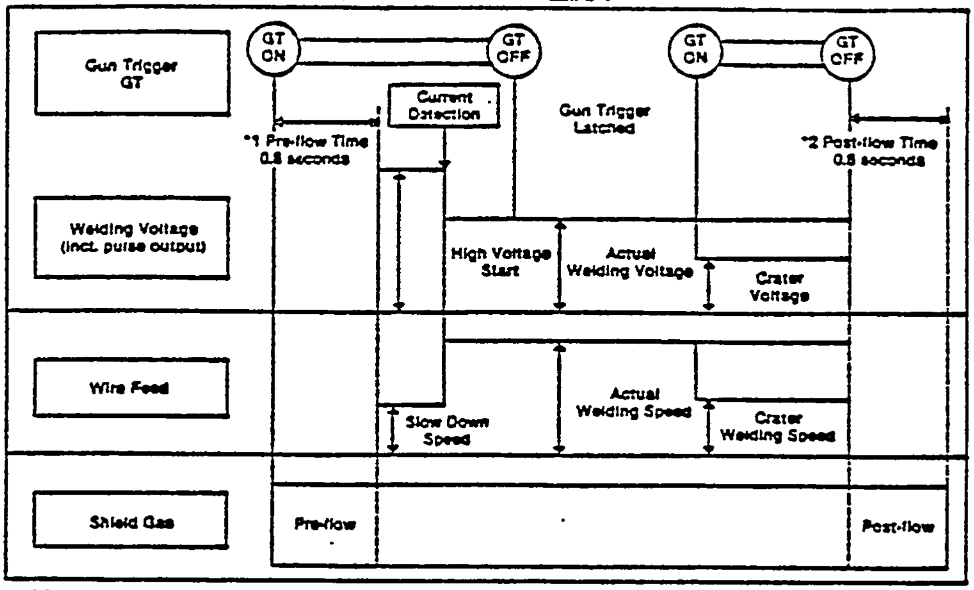
FIGURE 16

AIRCO PA 350: BACKGROUND CONTROL SETTINGS

Sequence of Operation with Crater Fill

1. Initial squeeze of gun trigger activates gas pre-flow, slow run-in, latches gun trigger, then welds at set parameters.

2. Second squeeze of gun trigger activates crater fill program; releasing trigger breaks arc, supplies gas post-flow.

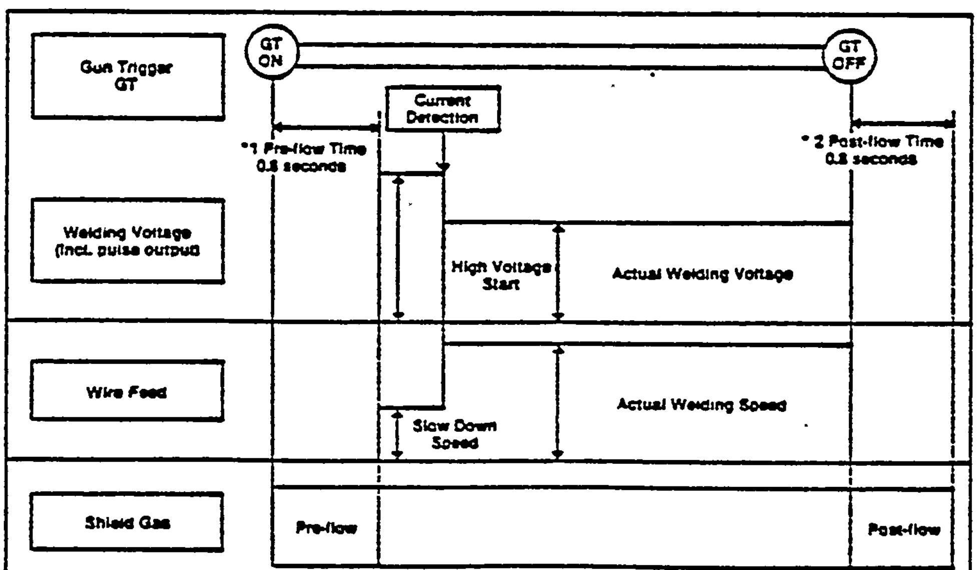


*1: 0.8 seconds when pre-flow is "ON," and 0 seconds when pre-flow is "OFF" at delivery.
*2: 2.4 seconds when wire material selector switch is set to "stainless steel."

Sequence of Operation without Crater Fill

1. Squeezing gun trigger activates gas pre-flow, slow run-in, then welds at set parameters.

2. Releasing trigger breaks arc, supplies gas post-flow.



*1: 1 second when pre-flow is "ON," and 0 seconds when pre-flow is "OFF" at delivery.
*2: 2.4 seconds when wire material selector switch is set to "stainless steel."

FIGURE 17

AIRCO PA 350: SEQUENCE OF OPERATION WITH/WITHOUT CRATER FILL

Welder acceptance of the Airco PA-350 prompted the following comments:

- Substantial reduction in spatter.
- Excellent weld cleaning action.

  Pulsed frequency that is optimum for the welding current is automatically programmed, e.g. at 150 amperes approximately 150 pulses per second (PPS).
- The “pulsed short-circuit” frequency does not vary in extreme, i.e. consistent small droplet arc transfers.
- The “pulsed short-circuiting” arc has consistent short-arc lengths 2-3 times wire diameters.
- The welding arc is stable because a closed loop electronic feed-back system apparently is constantly monitoring the welding current/voltage and controlling it consistently and reliably to enable small molten droplets to transfer from the wire tip to the weld puddle.
- The Binzel torch is a wire push type gun. It is light and air cooled and eliminates operator fatigue when compared with the much heavier Airco water cooled AH 35-C2 pull gun.
- A simple integrated single dial sets the welding condition requested. A remote pendant controls and adjusts the pulse frequency, pulse width, background voltage and peakvoltage automatically. Heat input is regulated by the current-control potentiometer on the remote pendant.
- The stable pulsed spray arc and the “pulsed short-circuiting” arc mode offers out-of-position, one-side, full penetration welds from .063 inch through .125 inch thicknesses in 5000 series aluminum alloys.

* * * * * * *

The original plan was to use the Airco PA-3A power source to generate our benchmark (base line) information relative to welding techniques and test data. However, during the course of this project, the Airco PA-3A malfunctioned and while this unit was being repaired we discovered the unusual "pulsed short-circuiting’ mode on the Airco PA-350. At this point in time, the Airco PA-350 power source, System 1 wire feeder, and Aircomatic 400 ampere torch was substituted to determine and establish the basic objectives of this project.

GILLILAND CV 600 FI-PA

The Gilliland CV 600 FI-PA is a 600 ampere constant voltage DC gas metal arc welding power source which can provide pulse in 60 and 120 pulses per second. It also functions in the standard GMAW mode without pulse and short-circuiting modes. Gilliland appears to have taken their basic CV 600 power source and added the capabilities for pulse.

There is a two position toggle switch for either 120 or 60 pulses per second and also a similar switch for pulse or standard constant voltage mode. A third toggle switch is a “stabilizer" on/off switch which apparently provides proper induction and arc stability. Also, there is a fourth “energizer" on/off toggle switch. A “test” push button provides open circuit voltage readings.

The use of electronically controlled SCR'S is the method applied for control of pulse rates.

A single pulse voltage knob ranging from 0.10 scale is a simple way to set pulse voltage higher or lower. The other 0-10 scale knob controls standard voltage ranges. This power source is extremely easy to set-up for welding in the pulse mode.

The Gilliland CV 600 FI-PA pulse arc GMAW welding power source and the portable 8 inch spool wire feeder are illustrated in Figure 18.

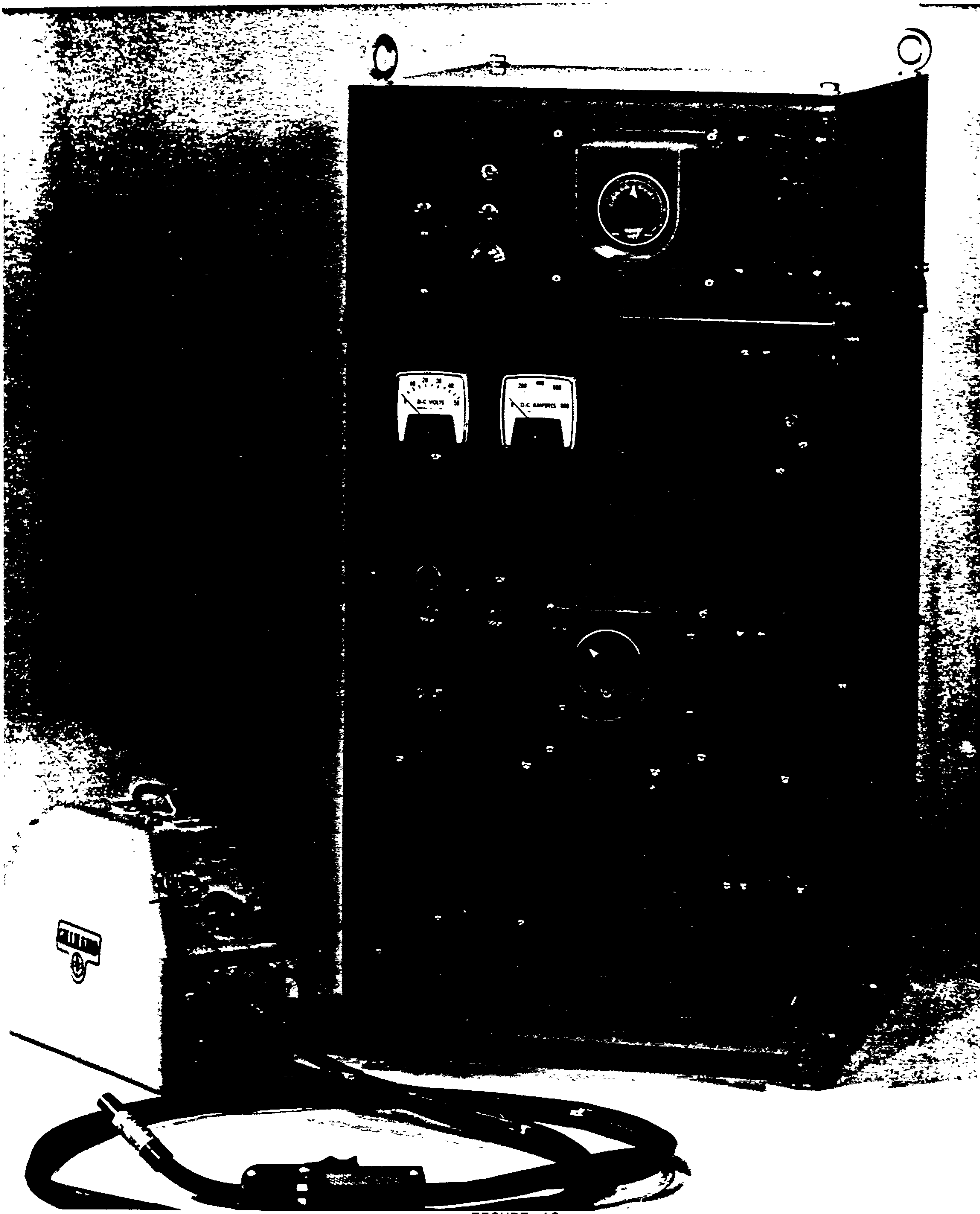


FIGURE 18
MALCOLM T. GILLILAND CV 600 FI-PA, PULSE ARC WELDING POWER SOURCE, FEEDER & GUN

MILLBR PULSTAR 450

The Miller Pulstar is a 450 ampere constant potential DC gas metal arc welding power source which can provide pulsed as well as the standard and short-circuiting arc modes. Miller Electric Manufacturing Company has taken their basic Deltaweld 450 and redesigned it to a star connection and added the capabilities for pulsed as well as short-circuiting and spray gas metal arc processes.

A three position welding mode selector switch can be set for standard operation spray or short-circuiting process and also 60 and 120 pulses per second of pulsed current. In the pulse mode, background voltage and peak amperage can be controlled at the power source or remotely via pendant control.

The features of the Miller Pulstar 450 are as follows:

Three position mode switch for standard operation (no pulsing), and 60 and 120 pulses per second of pulsed current.

Arc sustainer.

Weld ammeter swithh, selects average or peak reading.

Background voltage control.

Peak amperage control.

Solid state contactor.

Line voltage compensation ($\pm$ 10%).

Low voltage on/off push button.

Power failure reset.

115 volt duplex receptacle.

Volt and ammeters.

Standard/remote contactor control switch.

Standard/remote output control switch.

The Miller Pulstar 450 power source specification and physical information are shown in Figure 19. The volt ampere curve and the duty cycle chart are shown in Figures 20 and 21.

On the Miller Pulstar 450 field test power source unit, the following items are visible:

Remote contactor control.
115 volts AC receptacles (3).
DC voltmeter (0-100 volts).
DC ammeter (0-600 amperes).
Switch to set for 120 pps, 60 pps and standard (no pulse).
Power on/off buttons.
Remote output control (remote vs. standard).
Remote contactor control remote vs. standard).
Peak amperage adjustment potentiometer (200-550 amperes).
Background voltage adjustment (minimum-38 volts).

* * * * * * *

PULSE GMAW: POWER SOURCES: ATTRIBUTES

A chart covering the basic attributes of each of these four pulse GMAW power sources discussed previously is illustrated in Figure 22. Also, the pulse GMAW power sources and feeders used in this project are shown in Figure 23.

Model	Rated Welding Current Amperes 100% Duty Cycle	Voltage Range	Max. Open-Circuit Voltage	Input At Rated Load Output 60 Hz. Three-Phase						Overall Dimensions	Weight	
				Amperes At				kva	kw		Net	Ship
				200V	230V	460V	575V					
450 Ampere	450 @ 38 Volts	14-38	80	81	70	35	28	28	23	Height - 27-1/2 in. (699 mm)* Width - 22-1/4 in. (565 mm) Depth - 35-3/4 in. (908 mm)	447 lbs. (208 kgs.)	472 lbs. (214 kgs.)

*Add 2-3/4 in. (70 mm) for lifting eye.

FIGURE 19

MILLER PULSTAR 450 WELDING POWER SOURCE SPECIFICATION

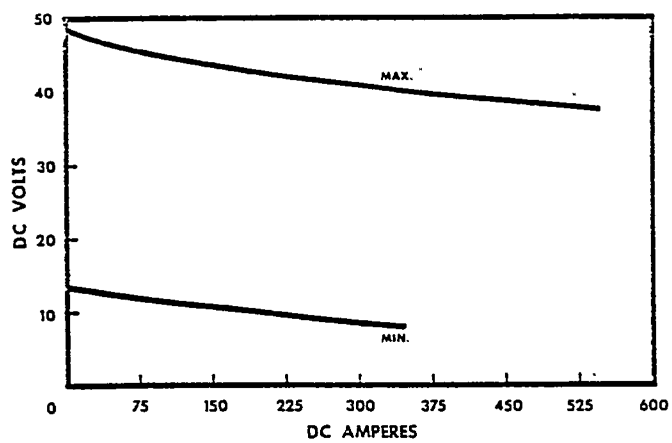


FIGURE 20

MILLER PULSTAR

VOLT AMPERE CURVE

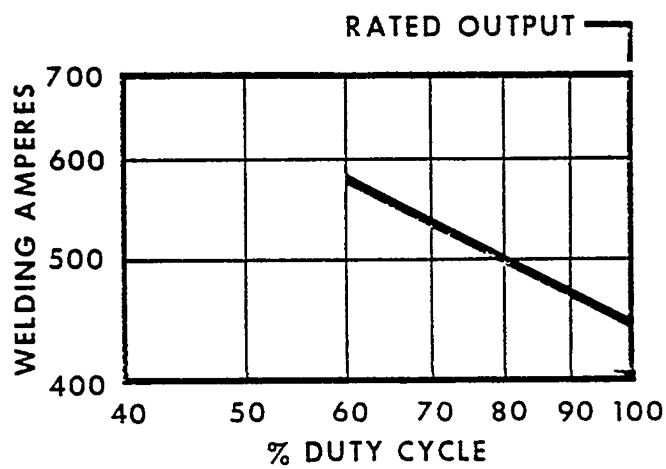


FIGURE 21

MILLER PULSTAR

DUTY CYCLE CHART

MANUFACTURER	AIRCO	AIRCO		MILLER	GILLILAND
MODEL NO.	PA-3A	PULSE ARC 350		PULSTAR	CV600 FI-PA
MODE	PULSE MODE	Pulse Mode	Dip/Spray Mode	PULSE & STANDARD MODE	PULSE-STD.-DIP/SPRAY
Rated Current	300	350	280	450	600
Rated Volts	30	36	275	38	40
Duty Cycle	100%	60%	60%	100%	100%
Maximum OCV	76 (peak) 50 (background)	78	78	80	78
Pulse Rate (pps)	60/120	50-250 pps	Pre-programmed Electronically Controlled	60/120 Electronically Controlled	60/120 Electronically Controlled
Type	Rectifier/SCR	Rectifier/Transistor		SCR	SCR-SCR
Control Method	Dual Power Source (pulse source is electronically controlled	Transistor Switching Regulator		Electronically Controlled SCR's	Electronically Controlled SCR's
Single Knob Control	N/A	Standard		N/A	Optional
Processes	Pulse/Spray	Pulse/Dip-Transfer/Spray		Spray/Dip-Transfer/Pulse	Pulse/Dip-Transfer/Spray
Ammeter	Standard (avg.)	Standard (Avg.)		Standard (avg./Peak Switch)	Standard (Avg.)
Voltmeter	Standard (Peak/Avg/Backgr'd Sw.)	Standard (Avg.)		Standard (avg.)	Standard (Avg.)
Pulse Width Control (Peak Volt.)	Standard	Electronically Programmed		Peak Current Adj.	Electronically Controlled
Remote Control	Optional	Standard w/voltage trim and integrated single knob control		Optional	Standard
Energy Saving Circuit	N/A	Standard		N/A	Optional
Arc Sustainer	X-Low Mode	N/A		Standard	Standard plus Stabilizer
Background Volt Range	20 to 47	Electronically Programmed		14 to 38	12 to 38
Peak Volts Range	20-80	Electronically Programmed		Maximum OCV-80	Electronically Programmed
Wire Feed (Current) Control	N/A	Electronically Programmed		N/A	Electronically Controlled
Fault Light	N/A	Standard		N/A	Optional
Material Switch	N/A	Stainless Steel/Mild Steel		N/A	Optional
Wire Size Switch	N/A	0.035/0.045		N/A	Optional
Line Volt Compensation	Standard	Standard		Standard	Standard
115 Volt Duplex	Standard (1 KVA)	Standard (.5 KVA)		Standard (1 KVA)	Standard (1 KVA)
Solid State Contactor	N/A	Standard		Standard	Standard
Gas Solenoid	N/A	Standard (w/purge/weld switch)		N/A	Standard (w/Pre/Post Timing)

Calc.			REVISED	DATE	GMAW PULSE ARC POWER SOURCE: ATTRIBUTE CHART	
Trac						
Chk					TODD PACIFIC SHIPYARDS CORP. SEATTLE DIVISION	
Appr.						
Appr.						

DATA SHEET

FIGURE 22

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3/83

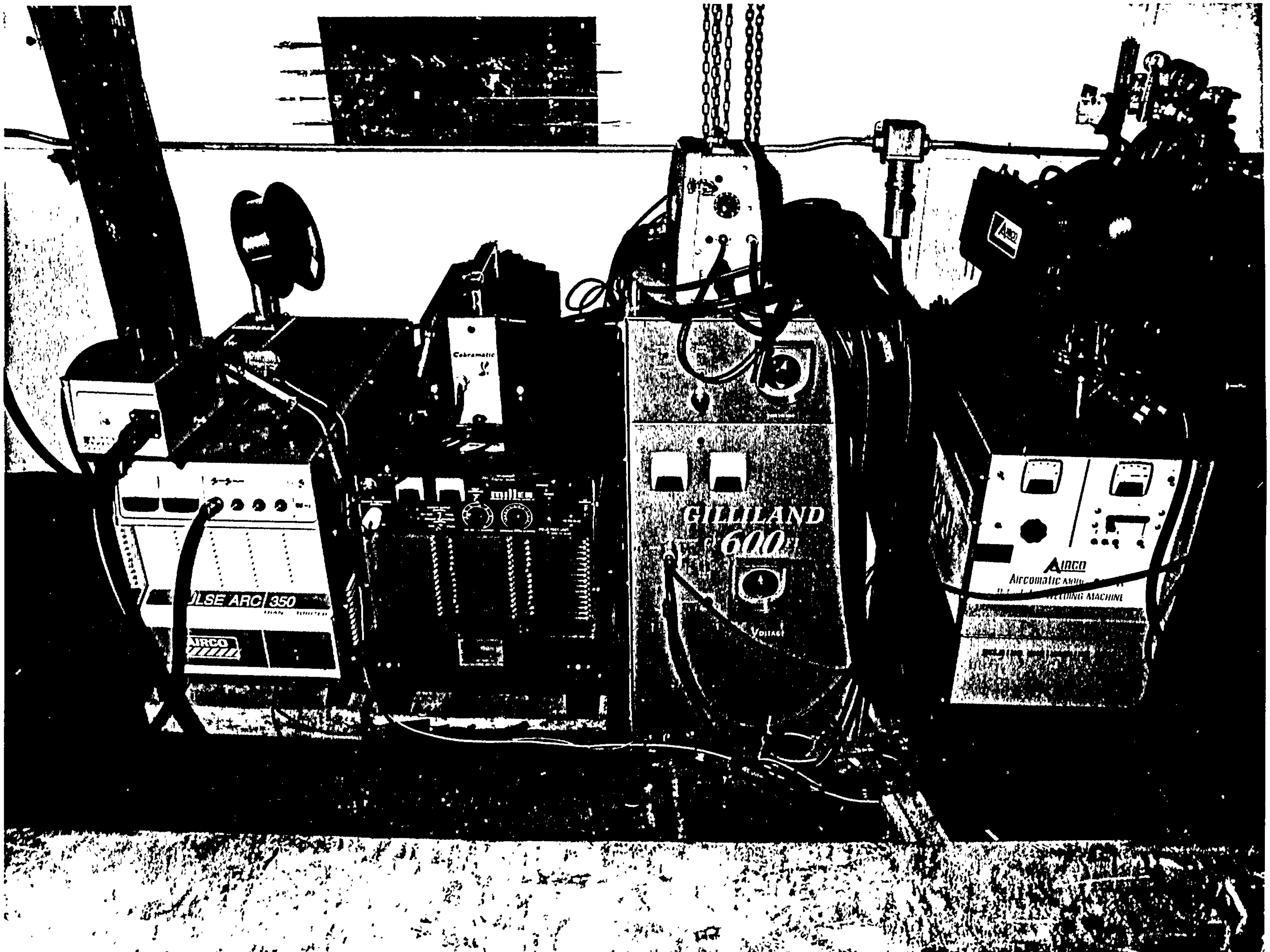

FIGURE 23
PULSE GMAW POWER SOURCES: TEST TRIAL

5000 SERIES ALUMINUM ALLOY SHEET & PLATE

The 5000 series aluminum alloy is a non-heat treatable alloy. The major alloying element is magnesium (5% maximum). The addition of magnesium provides strength. Further strength is gained by cold working. Cold working or strain hardening is attained by stretching, rolling or drawing sheets or plates through dies, or other similar operation.

The 5000 series aluminum alloy sheet and plate temper and material thicknesses investigated in this program were as follows:

MATERIAL THICKNESS	ALUMINUM ALLOY & TEMPER
.063 inch	5086 H-32
.100 inch	5086 H-32
.125 inch	5083 H-323
.250 inch	5086 H-116
.250 inch	5456 H-116
.250 inch	5083 H-321
.500 inch	5086 H-116
.500 inch	5456 H-116
.500 inch	5083 H-321

In the four digit system for aluminum and aluminum alloy, grouping indicates the alloy group. This is as follows:

DESIGNATION FOR ALLOY GROUPS

METAL	ALUMINUM ASSOCIATION NUMRER
ALUMINUM 99% MIN. AND GREATER	l xxx
MAJOR ALLOYING ELEMENTS	
COPPER	2 XXX
MANGANESE	3 XXX
SILICON	4 XXX
MAGNESIUM	5 XXX
MAGNESIUM AND SILICON	6 XXX
ZINC	7 XXX

ALUMINUM ASSOCIATION TEMPER DESIGNATION SYSTEM

-0 Annealed; Applies to softest temper (Wrought products).

-H Strain Hardened, Strength increased by strain hardening (Wrought products).

The -H is always followed by two or more digits. The first digit indicates the specific combination of basic operation as follows:

-H Strain hardened only. The number following this designation indicates the degree of strain hardening.

-H2 Strain hardened and then partially annealed.

-H3 Strain hardened and then stabilized.

The second digit following the designation -Hi, -H2, and -H3 indicates the final degree of strain hardening. Tempers between -0 (annealed) and 8 (full hard) are designated by numerals 1 through 7, e.g. -H12 = 1/4 hard, -H36 = 3/4 hard, -H38 = full hard.

The third digit indicates a variation of a two-digit H temper, i.e. amount of strain applied. It is used when the degree of temper control or the mechanical properties are different. -H323, for example, applies to aluminum-magnesium alloys (5000 series) specially designed for acceptable resistance to stress corrosion cracking.

The 5000 series aluminum alloy sheet and plate materials have experienced wide usage in marine fabrication. This series is the most widely used in marine service.

5083 ALUMINUM ALLOY

This alloy is a strong weldable alloy used primarily in armor and cryogenic applications. There are no restrictions for use in marine environment but it is not recommended to be used for applications involving temperatures above 150F.

5086 ALUMINUM ALLOY

This weldable alloy is generally used in hull and superstructure and meets general marine fabrication requirements. There are no restrictions for use in marine environment but it is not recommended for use in applications over 150F. 5086 H-116 aluminum alloys are used in hull fabrication.

5456 ALUMINUM ALLOY

This weldable alloy offers the highest strength and is used primarily for hulls, superstructures and special purpose vehicles where high strength-to-weight ratio is desired, e.g. air cushion vehicles and hydrofoils. The 5456 H-116 aluminum alloy is used for hull applications. This alloy is not recommended for use in application over 150F but otherwise there are no restrictions for use in marine environment.

Typical mechanical properties data for 5000 series aluminum alloy sheet and plate per U.S. Federal Specifications vs. The Aluminum Association are compared in Figure 24.

SHEET & PLATE MATERIAL SPECIFICATION	ALUMINUM ALLOY DESIGNATION	TEMPER	THICKNESS	MELTING RANGE F (APPROXIMATE)	ULTIMATE TENSILE TENSILE STRENGTH psi			YIELD STRENGTH 0.2% OFFSET			ELONGATION (IN 2")		BRINELL HARDNESS 500 Kg LOAD 10 mm BALL
					ALUMINUM ASSOCIATION	QQ-A-250 MIN	QQ-A-250 MAX	ALUMINUM ASSOCIATION	QQ-A-250 MIN	QQ-A-250 MAX	ALUMINUM ASSOCIATION	QQ-A-250	
QQ-A-250/6	5083	0	1/8"	1070-1185	42000	40000	51000	21000	18000	29000	22	16	67
	5083	H-321	1/4";1/2"		46000	44000	-----	33000	------	------	16	-----	82
	5083	H-323	1/8"		47000	45000	54000	36000	34000	44000	10	8	84
QQ-A-250/19	5086	0		1085-1185	38000	35000	42000	17000	14000	-----	22-30	16	60
QQ-A-250/7	5086	H-32	.063"/0.10"		42000	40000	47000	30000	28000	-----	12-16	8	72
QQ-A-250/19	5086	H-116	1/4";1/2"		42000	40000	-----	30000	28000	-----	12-16	10	72
QQ-A-250/20	5456	0		1055-1180	45000	42000	53000	23000	19000	-----	24	16	70
QQ-A-250/20	5456	H-116	1/4";1/2"		51000	46000	-----	37000	33000	-----	16	10	90

Calc.			REVISED	DATE	TYPICAL BASE METAL PROPERTIES OF 5000 SERIES ALUMINUM ALLOYS THE ALUMINUM ASSOCIATION vs. FED.-SPEC.
Trac					
Chk					
Appr.					TODD PACIFIC SHIPYARD CORPORATION SEATTLE DIVISION
Appr.					

FIGURE 24

DATA SHEET

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ALUMINUM ALLOY FILLER WIRES

In general, for welding 5000 series aluminum alloy sheet and plate, the Plans (Drawings) will, unless otherwise specified, permit the fabricator to use interchangeably ER 5183, 5356 or 5556 per ASTM/AWS 5.10, “Specification For Aluminum and Aluminum Alloy Bare Welding Rods and Electrodes.” The prefix ER is used by AWS to denote “Electrode/Rod” to cover both the gas metal arc welding GMAW or the gas tungsten arc welding GTAW process.

For this project, only the ASTM/AWS ER 5356 and 5556 aluminum alloy bare wires in 12 inch diameter spools (10-12 lbs.) were used, i.e. ER 5183 filler wires were not available Without schedule impact. ASTM/AWS 5.10 requirements covering chemical composition for ER 5356 and 5556 are shown in Figure 25.

Burn off characteristics of 5356 aluminum alloy filler wires are illustrated in Figure 26.

The weld is a composite or alloy of the filler material and the base material. This composite largely determines the mechanical properties of the weld. Also, the gas metal arc process does leave an annealed condition weld area. Weld joint configuration, weld filler wire types and welding techniques are other variables that must be considered. High. magnesium gas metal arc filler wires such as ER 5183, 5356 and 5556 generally produce strong ductile welds.

Usually the “as welded" tensile strengths of the 5000 series aluminum-magnesium alloy welds are equal to the strength of the annealed base material. The only way to strengthen “as welded” tensile strength in 5000 series aluminum is to cold work, e.g. roll-planishing, which is not practical in a shipyard setting.

All aluminum alloy filler materials when opened were kept in a dry warm storage box. This is illustrated in Figure 27. Only Alcoa "Almigweld" aluminum alloy filler wires were utilized.

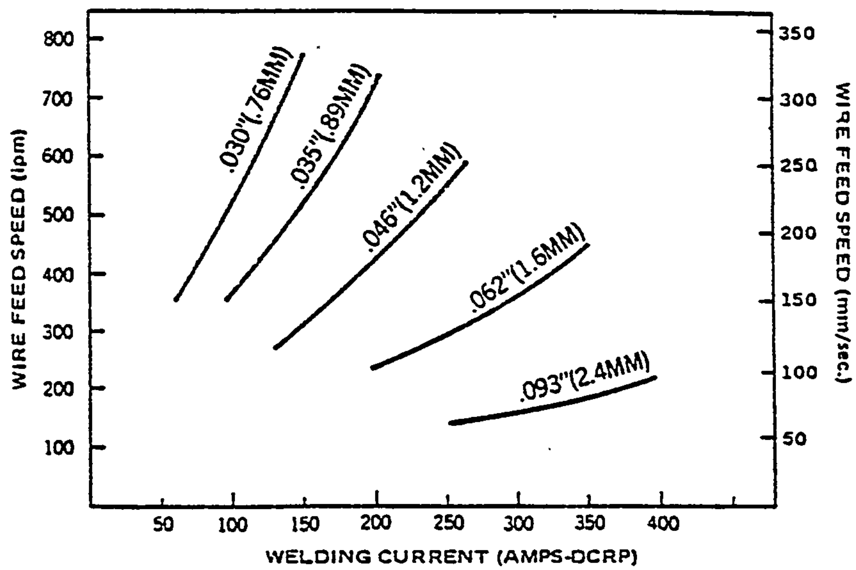


FIGURE 26

BURN-OFF CHARACTERISTICS

5356 ALUMINUM WIRE

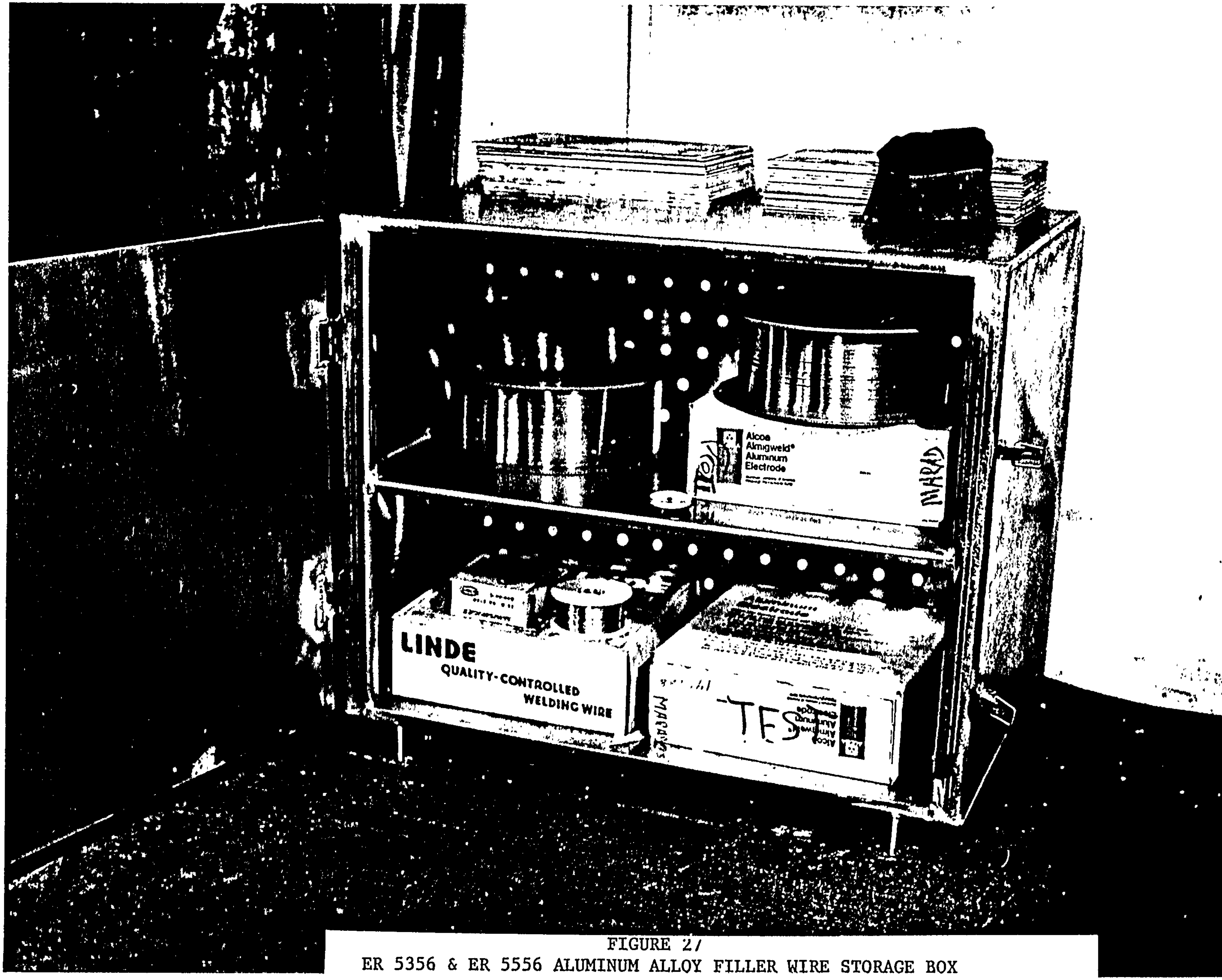


FIGURE 27
ER 5356 & ER 5556 ALUMINUM ALLOY FILLER WIRE STORAGE BOX

WELD JOINT DESIGNS

Square butt weld joint designs *were* used on the .063, .10, and .125 inch thick 5000 series aluminum alloy sheet test piece parts. See Figure 28 for square butt weld joint design.

The .250 inch and the .500 inch thick aluminum alloy plates were machined with "J” type weld joint designs. Initially, the dimensioning of the root face was .075 inch and .100 inch for the .250 and .500 inch material thicknesses as illustrated in Figure 29. The final or preferred joint design was based primarily on the consistency and reliability towards attaining out-of-position, one-side, full penetration welds. See Figure 30, which illustrates the “J” joint configuration used on 1/2 inch material thicknesses. The 1/16 inch width of flat dimension between the centerline of the weld joint and the tangent point of the .125 inch radius was shortened as required to provide acceptable weld bead reinforcements. This is illustrated on the individual Welding Procedure Qualification Test Summary pages further in the text.

A high speed end mill cutter head was used on a Bridgeport Series 1 type mill to machine the "J" type joints on the longitudinal side (12” length) of the 8 inch x 12 inch test piece parts. See Figure 31.

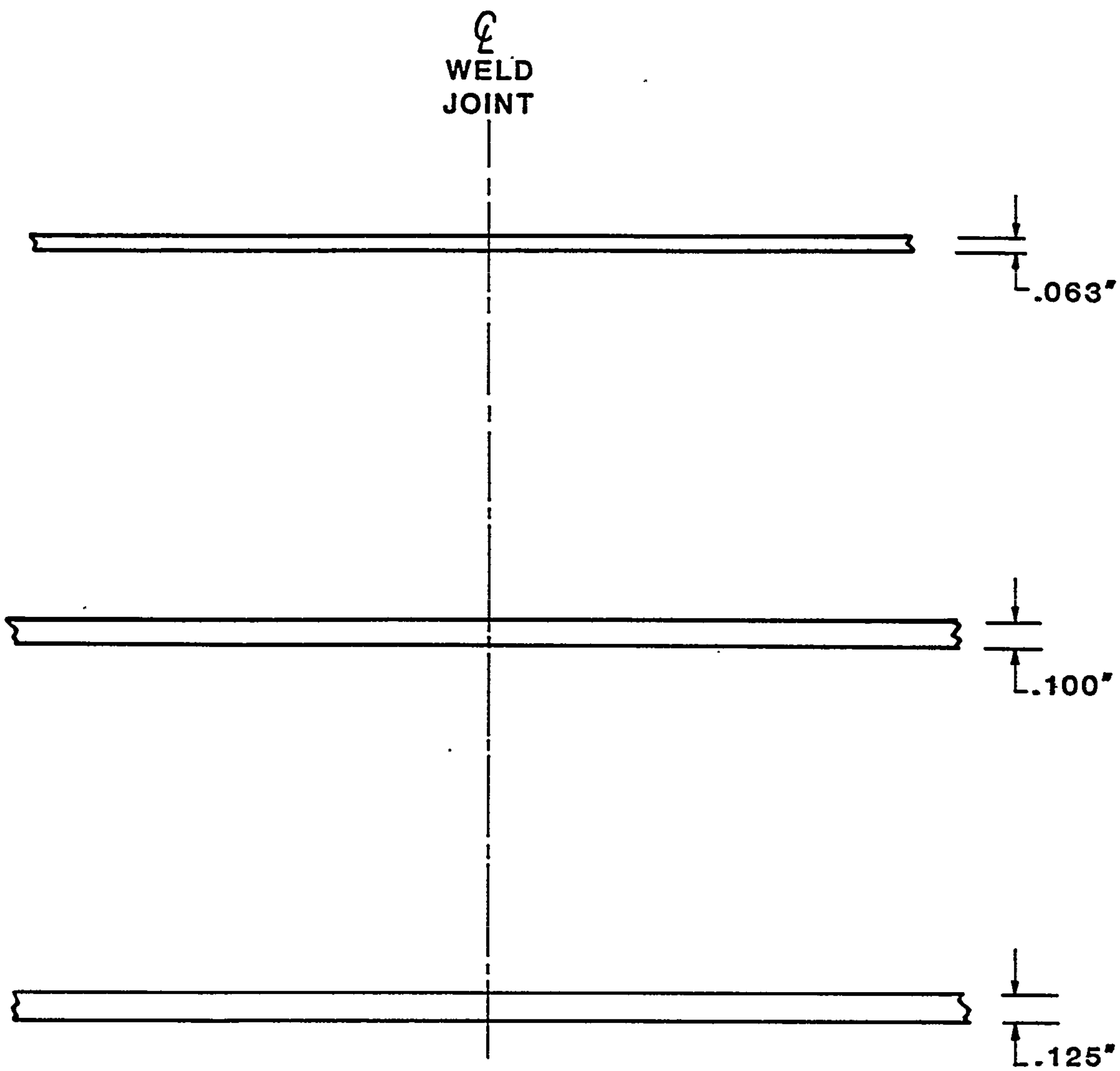


FIGURE 28

BUTT WELD JOINT CONFIGURATION
FOR .063 , .100 , AND .125
INCH THICK 5000 SERIES
ALUMINUM ALLOYS

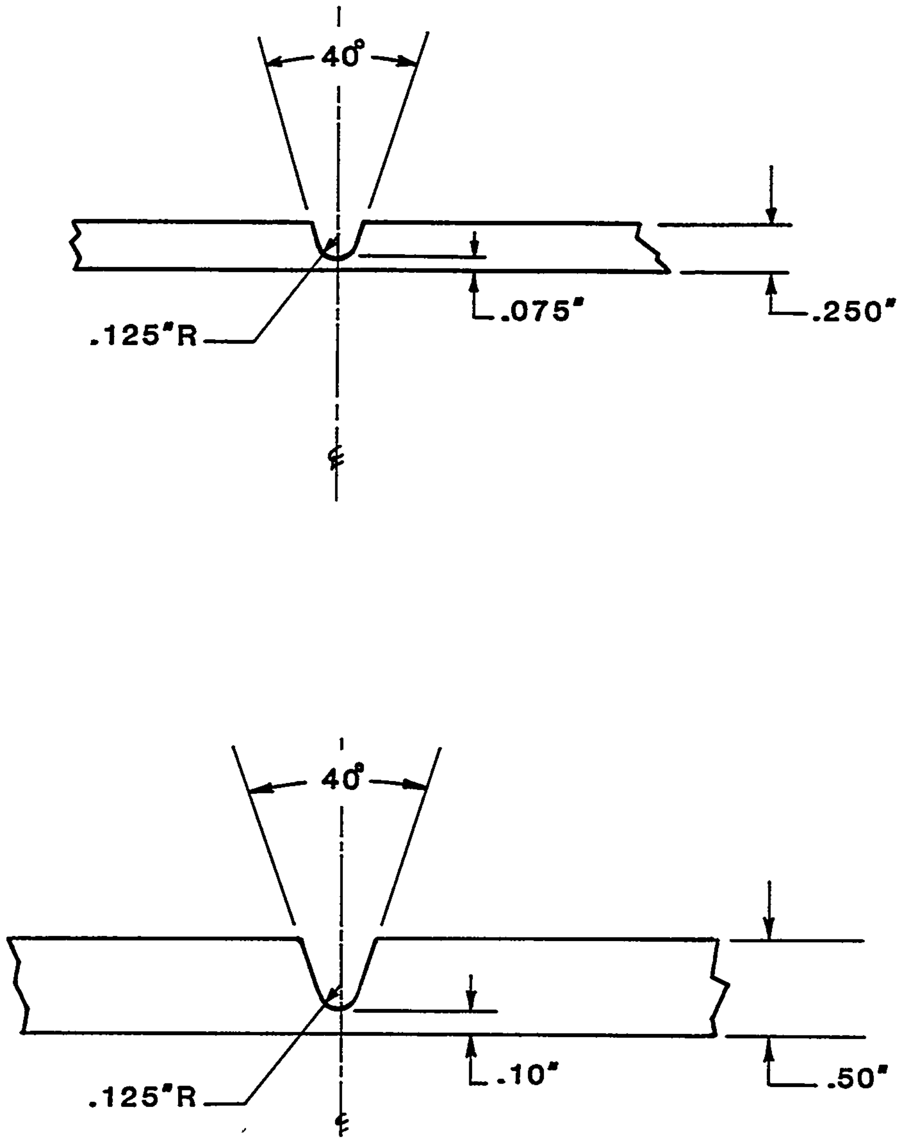


FIGURE 29

WELD JOINT CONFIGURATION FOR .250 AND .500 INCH THICK 5000 SERIES ALUMINUM ALLOY PLATES

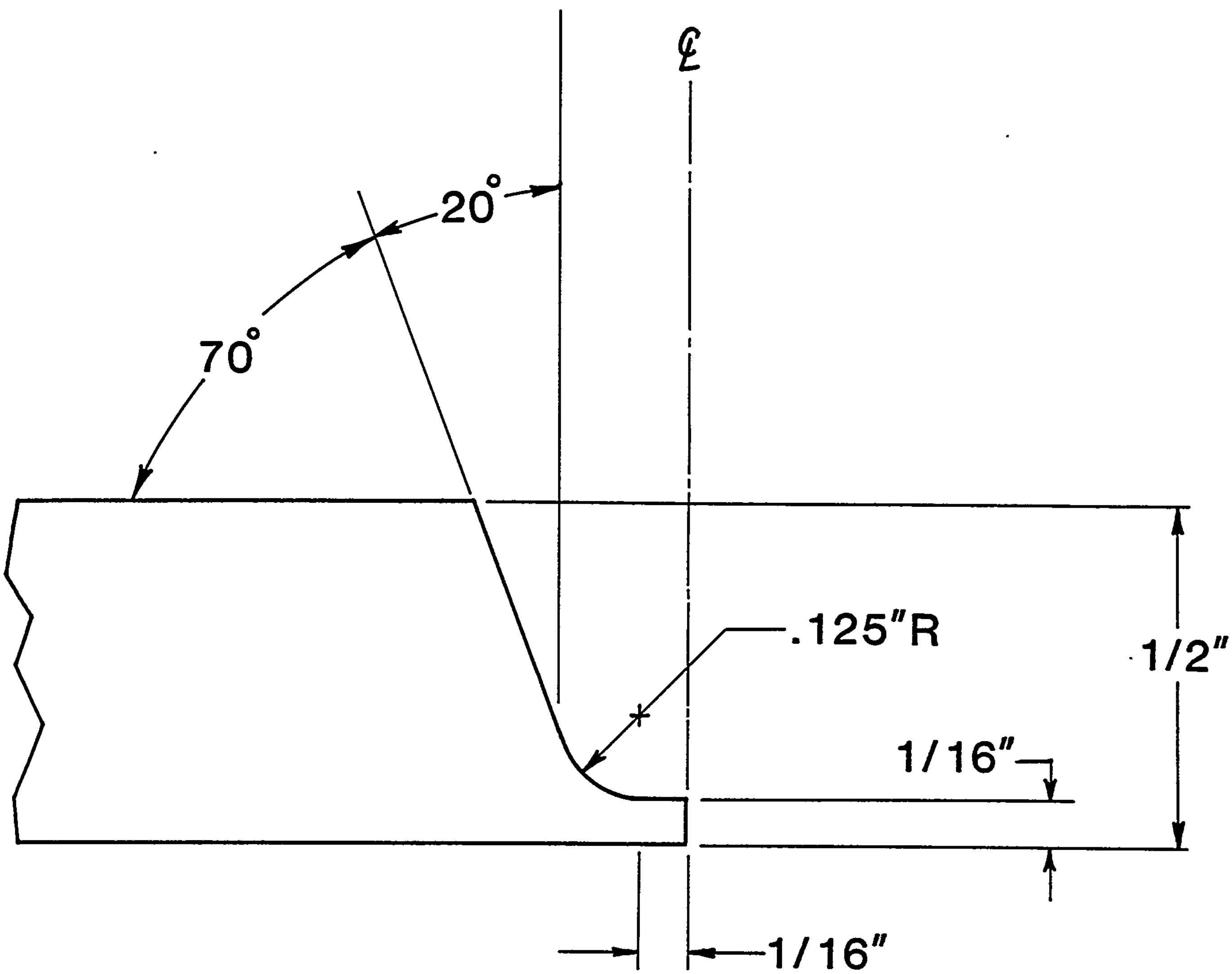
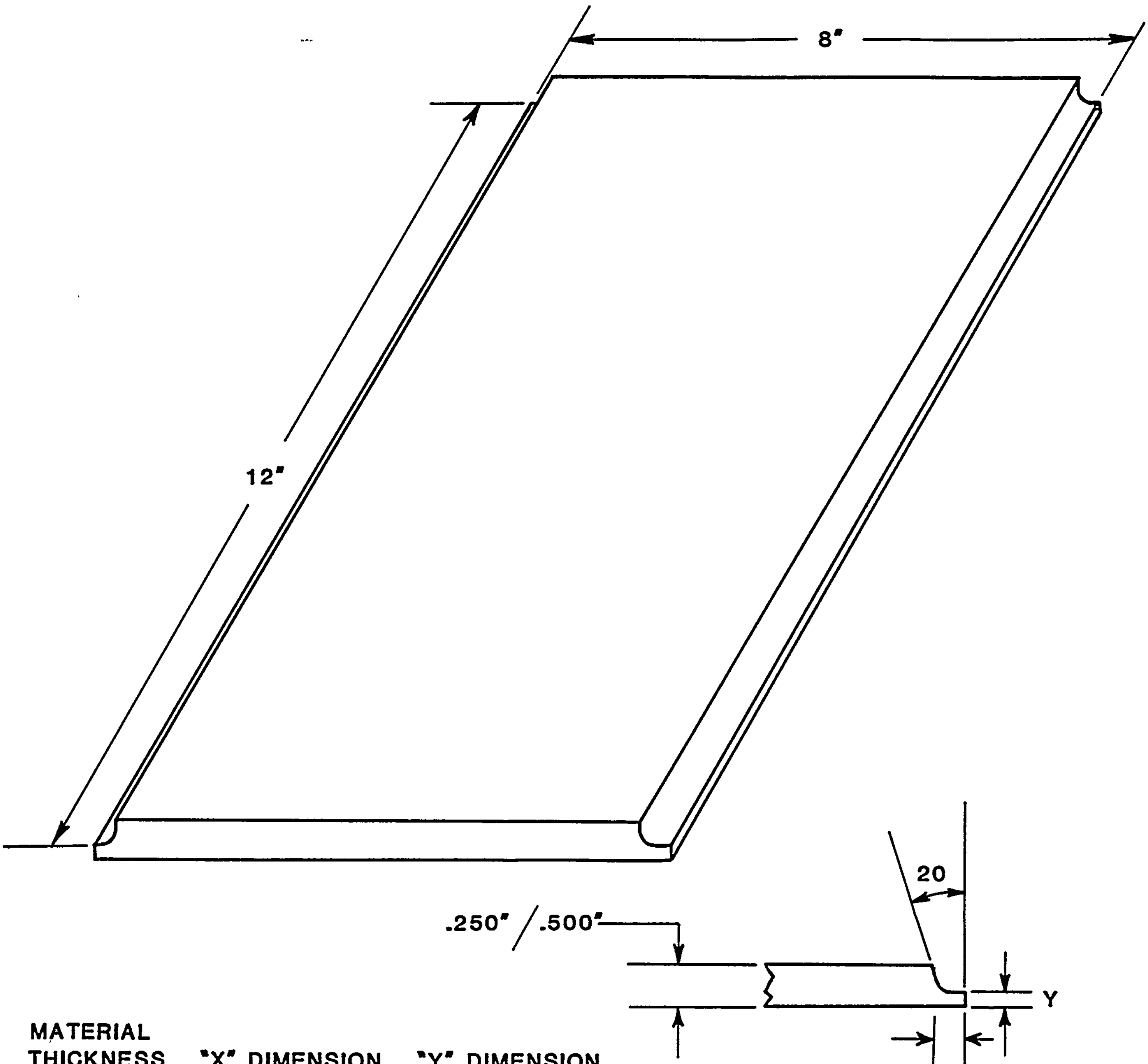


FIGURE 30

"J" JOINT DESIGN FOR 1/2 INCH THICK PLATE



MATERIAL THICKNESS	"X" DIMENSION	"Y" DIMENSION
.250"	.200"	.075"
.500"	.300"	.100"

FIGURE 31

SHIELDING GASES

The choice of weld shielding gas or combinations thereof for manual pulsed gas metal arc welding were argon, helium, argon/helium or argon oxygen mixtures. The gas selection chart for these gases is illustrated in Figure 32.

BASE METAL	GMAW MODE	SHIELDING GAS			
		ARGON	HELIUM	ARGON HELIUM MIXTURES	ARGON OXYGEN
ALUMINUM	SHORT-CIRCUITING ARC MODE OF METAL TRANSFER	X	X	X (75% HELIUM 25% ARGON)	
ALUMINUM	PULSES SPRAY ARC MODE OF METAL TRANSFER	X	X	X	(OXYGEN) 0.1%-1.0%

FIGURE 32

GAS METAL ARC SHIELDING GAS SELECTION CHART

ARGON SHIELDING GAS

Argon is a colorless, odorless, inert gas comprised of heavy single atoms having a molecular weight of 39.948. It will not combine with any other element to form molecular or compounds. Argon gas is heavier than air. The density of argon is 0.111 lbs./ft.^{3}. Argon is a monatomic inert gas with low voltage gradient and its chief characteristic is that it sustains a stable welding arc. Argon is a poor heat conductor and produces an extremely high current concentrated welding arc core resulting in a weld penetration pattern which is deep in the center and shallow around the edges of the weld nugget.

Argon is used generally for welding aluminum in the flat welding position.

HELIUM SHIELDING GAS

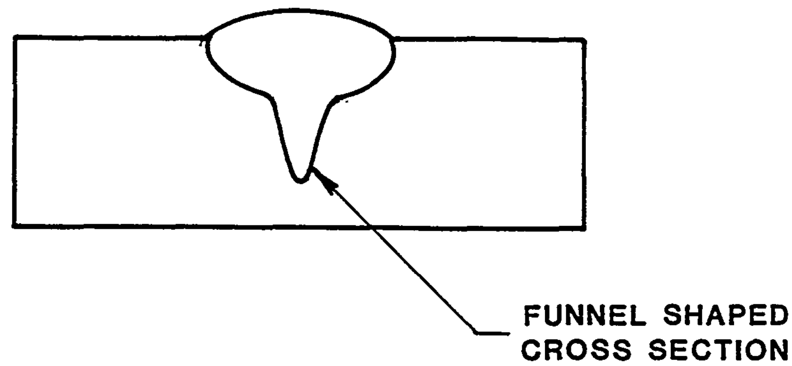
Helium is also a monatomic colorless, odorless inert gas. The molecular weight of helium is 4.0026. Helium gas is lighter than air or argon, i.e. molecular weight of air is 28.96. Helium is 1/10 the weight of argon. Helium is characterized by a high voltage gradient and offers more wattage in the welding arc when compared with argon. Helium is a high heat conductivity gas, and when used with welding results in a broad even penetration weld cross section. See Figure 33 illustrating the effects of argon and also helium gas shielding on weld nugget penetration and shape.

ARGON/HELIUM COMBINATIONS

The 75% helium/25% argon shielding gas mixtures provide the advantages of both gases: a broad, even and deeper weld nugget cross section. Figure 34 illustrates the weld penetration geomentry when 75% helium/25% argon shielding gas is used for manual gas metal arc welding. Helium/argon gas mixtures when used with gas metal arc welding take advantage of the favorable characteristics of both gases, e.g. high heat input, deep penetration, low spatter, stability, good radiographic weld quality, good weld bead width/depth ratio. Argon/helium mixtures are widely used for out-of-position radiograph quality welds. Helium rich mixtures help achieve significant benefits from the helium. The type of gas(es) to be used for shielding should be based on which gas or gas combinations provide the greatest overall advantages for a specific application.

ARGON

CHARACTERISTIC: STABILITY



HELIUM

CHARACTERISTICS:INCREASED HEAT INPUT

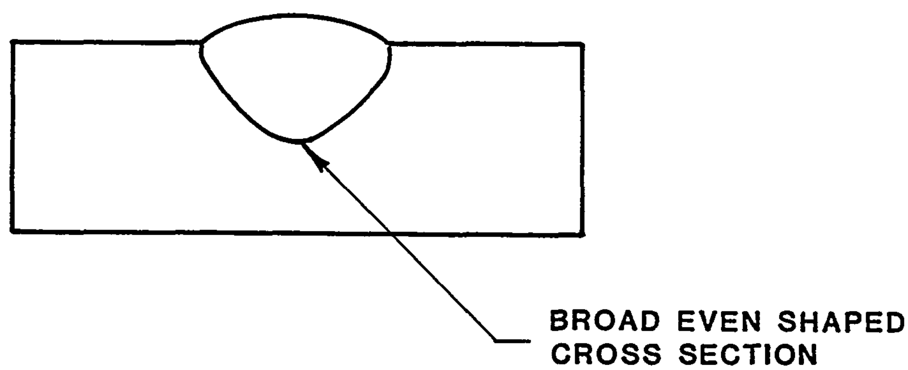


FIGURE 33

WELD PENETRATION SHAPE
ARGON AND HELIUM

HELIUM-ARGON MIXTURE

CHARACTERISTICS: GOOD WELD BEAD SHAPE

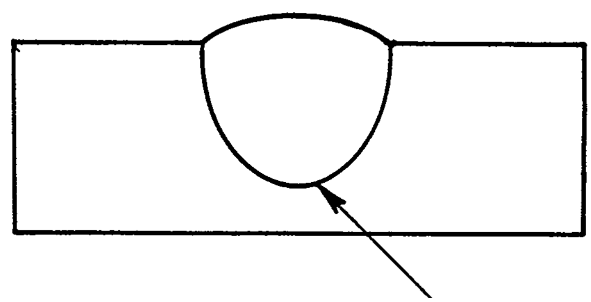


FIGURE 34

HELIUM-ARGON MIXTURE
WELD PENETRATION GEOMETRY

The shielding gas used for this project was primarily limited to 75% helium/ 25% argon combinations. Argon gas was per MIL-A-18455 and helium gas was per Federal Specification BB-H-1168, Grade A.

The basic reason for the choice of 75% helium/25% argon combination shielding gas was because past experience had indicated that acceptable radiograph testing quality levels could be more readily obtained for all-position manual gas metal arc welding of 5000 series aluminum alloys. However, on .500 inch thick aluminum alloy material 100% helium shielding gas was utilized to make excellent welds. With the increased material thicknesses, it was felt that better sidewall fusion could be attained in the full penetration root passes as well as in the multiple fill passes.

In general, the 75% helium/25% argon shielding gas mixture, as well as the straight helium gases, were preferred because good width/depth ratio could be attained in the weld cross sections. This type of weld cross section with almost parallel side wall also offered less distortion, i.e. more balanced heat input.

MATERIAL PREPARATION

A cutting diagram was developed for 5000 series aluminum alloy sheet and plate materials ranging from 1/16 inch, .100 inch, .125 inch, .250 inch and .500 inch thicknesses and were all sheared into 8 inch x 12 inch piece parts to be butt welded on the 12 inch side to make 12 inch x 16 inch butt welded test panels. All the shearing of the test piece parts (8 inch x 12 inch) were done in either the Wysong and Miles Co., Model No. 1010 or the Cincinnati Inc., hydraulic shears. The rolling direction ("grain") was transverse to the weld joint centerline. A typical cutting diagram is illustrated in Figure 35.

All aluminum alloy sheet material up to and including .125 inch thicknesses were draw filed with a bastard vixen type file so that all sharp edges, shear marks, and lamination that could cause deleterious effects in the weld were completely removed. Mechanical sanding, chipping, machining, routing are other alternative methods used for weld joint preparation. See Figure 36.

Methyl-ethyl-ketone (MEK] was applied with a clean rag around the weld joint areas and surface to ensure that it was free of grease, oil, moisture, paint, shop soil, or other harmful matter. It should be pointed out that MEK may not be approved for use in confined, closed areas, i.e. alternate approved solvents should be used in production applications such as Dow Chemical Chlorothene VG. Decreasing with an approved solvent prior to and after mechanical cleaning appeared best.

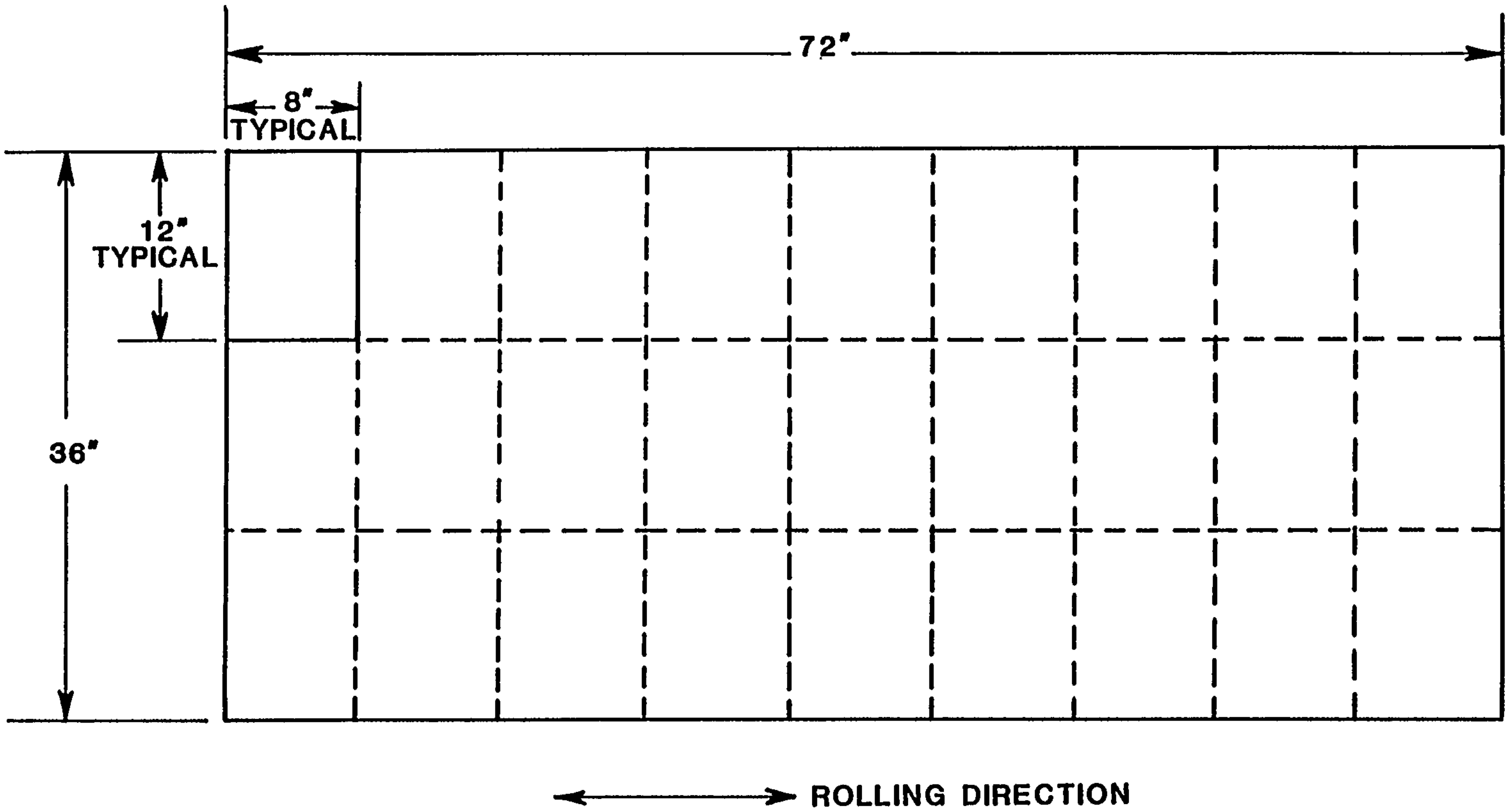


FIGURE 35

TYPICAL CUTTING DIAGRAM FOR 5000 SERIES ALUMINUM
ALLOY SHEET AND TEST PLATES

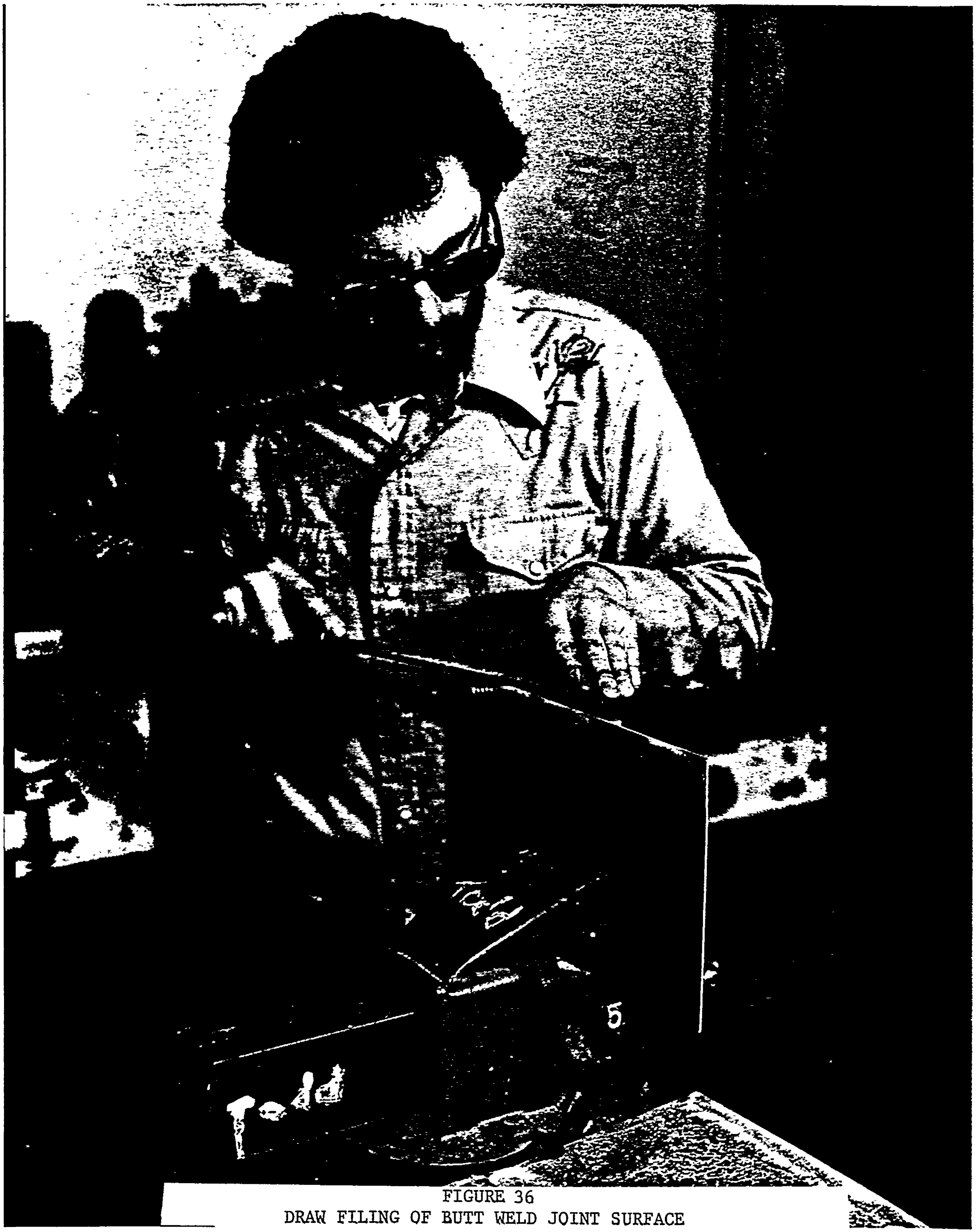


FIGURE 36
DRAW FILING OF BUTT WELD JOINT SURFACE

Cleaning the test plate weld joint area with a portable disk grinder was done preferably with an open-coat disk of *80* grit aluminum oxide. This sanding disk removes heavy oxide film readily where stainless steel wire brushing appeared ineffective. See Figure 37.

Immediately prior to welding, the weld joint and areas adjacent to the weld joint were wire brushed with a clean stainless steel wire brush. This was done either with a hand held brush or power driven rotary brush. Stainless steel wire brush bristles were approximately .010 - .015 inch diameters. See Figure 38.

Whenever overnight delays in between assembling test piece parts and welding occurred, the weld test assembly was covered and wrapped with clean Kraft wrapping paper to keep off shop soil and dust. Care was taken to preclude the adhesive from adheing to the weld joint areas and causing subsequent weld contamination, i.e. no eight hour time limits were necessary.

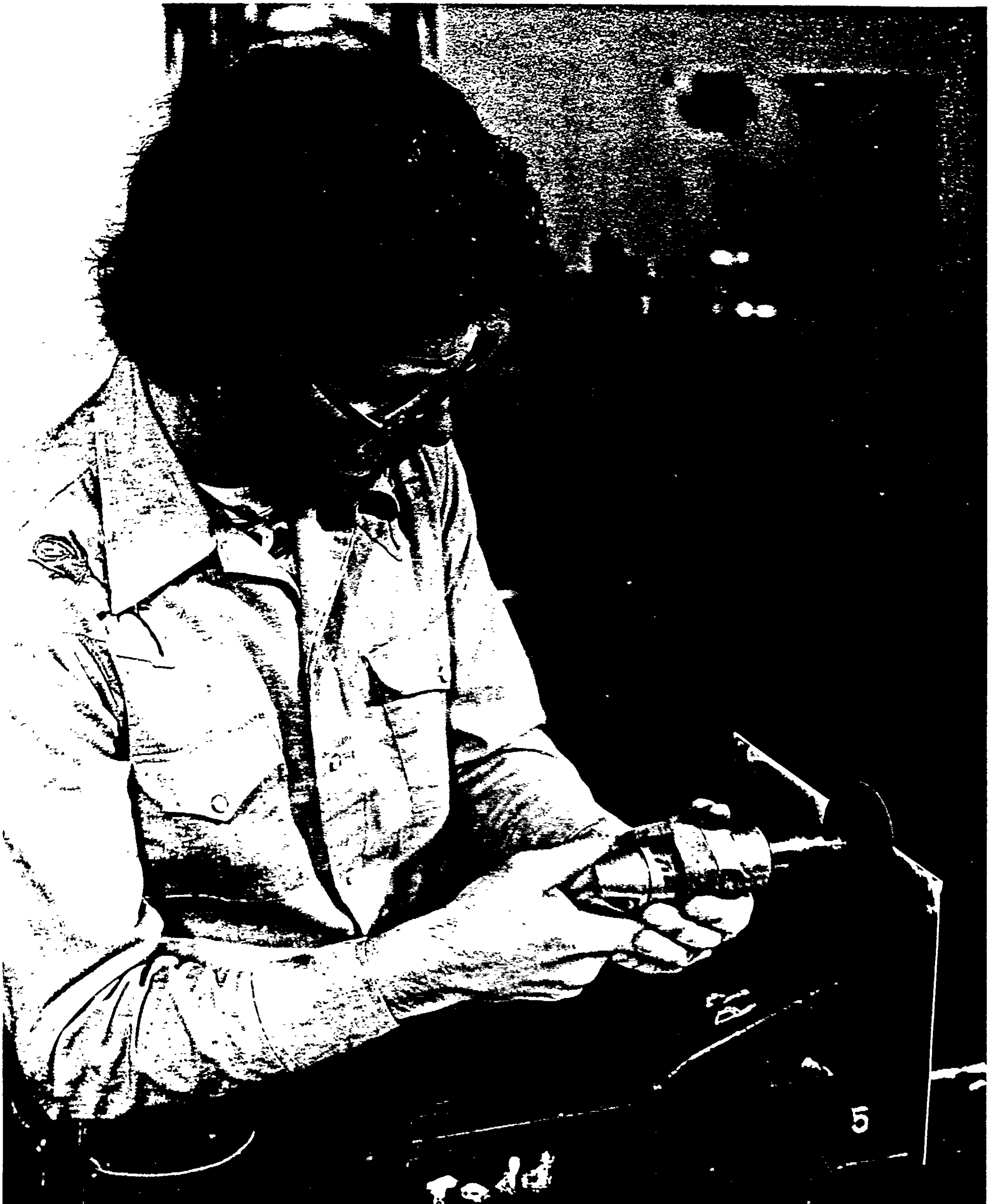


FIGURE 37
MECHANICAL CLEANING OF TEST PIECE PARTS WITH USE OF PORTABLE DISK SANDER.

FIGURE 38
POWER BRUSHING WITH CLEAN STAINLESS STEEL WIRE BRUSH

WELD JOINT FIT-UP

Weld joint fit-up preferably should be metal to metal, i.e. zero gap. The maximum butt joint gap allowed anywhere over the length of the weld joint should be as follows:

MATERIAL THICKNESS(T)	MAXIMUM JOINT ROOT OPENING (GAP)
up to .125 inch	1/4 T
.125 inch and thickner	.030 inch

Weld joint fit-up requirements per NAVSEA 0900-000-1000/0001, "Fabrication, Welding and Inspection of Ships' Hulls," are as follows:

MATERIAL THICKNESS

less than .375 inch 1/16

.375 inch and thicker 1/8

Obviously, these requirements were written for stick electrode welding and are inadequate and not in consideration of the newer welding processes or thinner sheet materials.

All test piece parts were manual GMAW tack welded together with weld start and weld stop tabs. All the butt welds were made on the side opposite the tack welds, i.e. both butt and "J" groove weld joints. See Figure 39.

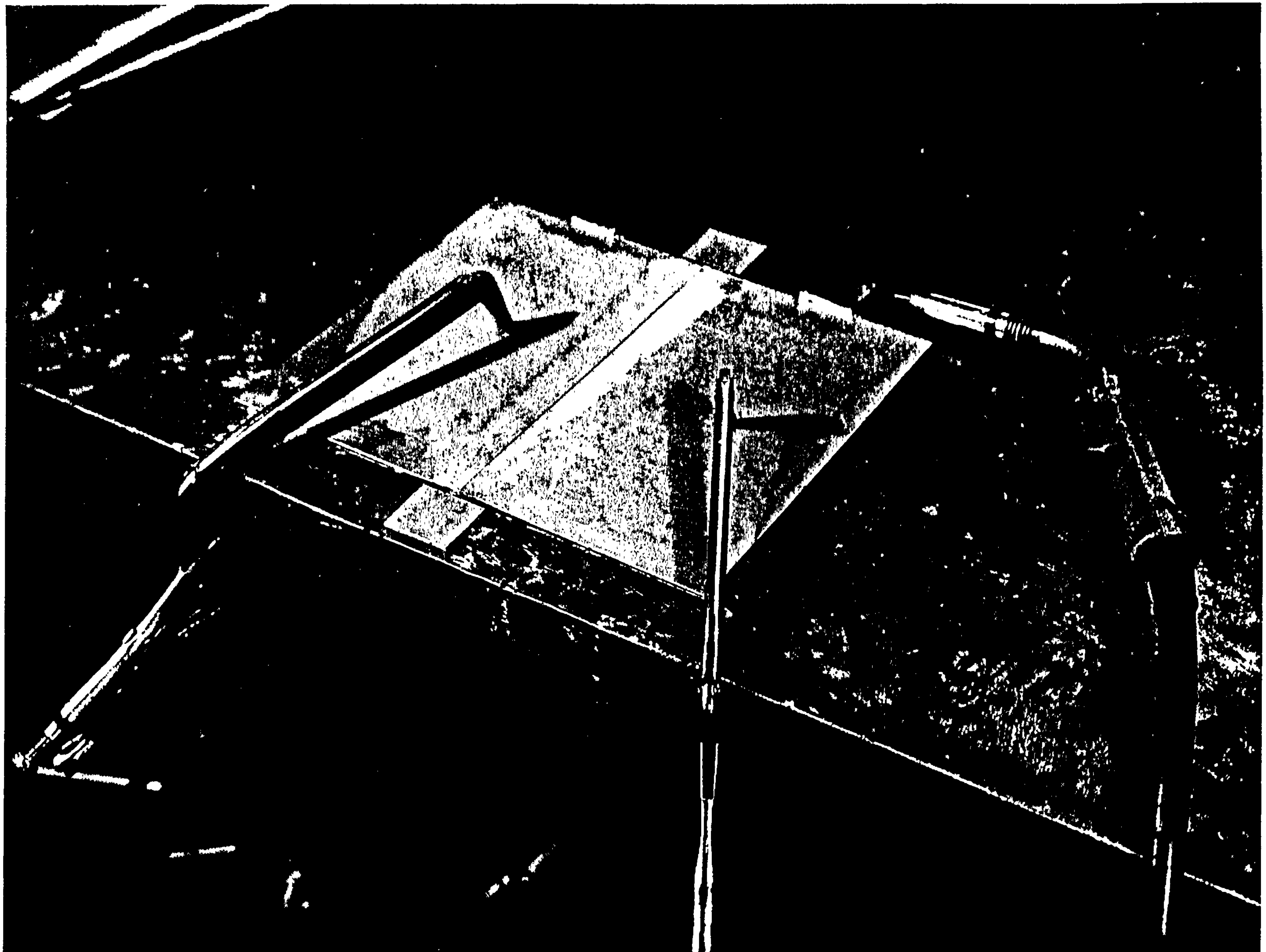


FIGURE 39
SET-UP FOR PULSE GMAW TACK WELDING

WELDING TESTS

This section describes the various welding tests conducted to generate welding procedure specification qualification data per NAVSHIPS 0900-000-1000/1, “Fabrication, Welding and Inspection Of Ship Hulls,” and MIL-STD-oo248 (SHIPS), “Welding Procedure and Performance Qualification,” for the out-of-position, one-side, full penetration manual pulsed gas metal arc welding of 5000 series aluminum alloy sheet and plate for marine fabrication.

The welding variables involved in this investigation covered the following:

1. 5000 series aluminum alloy base material type & temper,
   - 5083 H-321
   - 5083 H-323
   - 5086 H-116
   - 5456 H-116

2. 5000 series aluminum alloy sheet and plate thicknesses,
   - .060 inch
   - .100 inch
   - .125 inch
   - .250 inch
   - .500 inch

3. Filler wire alloy and diameters,
   - 5356 aluminum alloy wires
   - 5556 aluminum alloy wires

   - .030 inch diameter
   - .035 inch diameter
   - 3/64 inch diameter
   - 1/16 inch diameter

4. Shielding gas & combinations,
   - 75% helium/25% argon
   - 100% argon

5. Welding positions:
   vertical-up
   overhead
   horizontal
   flat

6. Welding power sources:
   Airco PA-3A
   Airco PA-350
   Miller Pulstar 450
   Gilliland CV 600 FI-PA

7. Wire feeders:
   Airco AHF-NP
   Airco System 1
   M & K
   Gilliland MTG2000

8. Welding gun (torches):
   Airco/Binzel
   Airco AH 35 C-2
   M & K Cobramatic
   Gilliland MTG-4001

Each of the pulse arc welding power sources, wire feeders, guns and accessories listed above were checked out during an equipment familiarization period. Scrap aluminum sheet and plate materials were used to make bead on plate type welds to establish basic welding machine settings for full penetration butt welds. As confidence levels increased, acceptable butt weld machine settings were established.

The welding test material flow diagram covering the range from "as procured" full. size sheet/plates to destructive testing is illustrated below:

1. Inspection and lay-out of cutting/shearing diagram for each full size 5000 series aluminum alloy sheet/plate.

2. Cutting/shearing full size sheet/plate into weld test piece parts approximately 8 inches x 12 inches for .063 inch, .100 inch, .125 inch,

.250 inch and .500 inch thicknesses. Identify each piece part.

3. Machine square all 12 inch lengths preparatory for:
   a) square butt joint (.063 inch - .125 inch)
   b) "J" groove joint (.250 inch - .500 inch)

4. Clean all weld edges and joint areas by degreasing with approved solventl

5. Mechanically clean by filing, scraping, milling or wire brushing with clean stainless steel rotary brush or hand brush all weld joint areas.

6. Manual GMAW tack weld each 8 inch x 12 inch aluminum alloy piece parts together with weld start/stop tabs to form a 16 inchx 12 inch weld test panel.

7. Manual pulse GMAW in vertical-up, horizontal or overhead welding position as required.

8. Non-destructive inspection of weld test panels: visual, penrtrant and radiographic. Reject or accept test panels. If rejected, cut out weld and recycle to step 3. If accepted, follow step 9.

9. Mill off weld surface and weld underbead from test panels.

10. Lay out and band saw test panels into rough oversize dimensions for transverse tensiles (2) and bend specimens (4). Steel stamp identification code.

11. Mill piece parts (rough dimensions) into final dimensions for transverse tensile (2), root bend (2), and face bend test specimens (2). (See section on Mechanical Properties in this report).

12. Conduct mechanical properties tests. Record data.

13. Evaluate, analyze and summarize weld test results as weld procedure specification qualification support data.

For clarity’s sake, the reporting together with comments, results, and recommendations are covered with each specific test grouping. Each grouping includes the particular 5000 series aluminum alloy and temper, filler wire diameter and type, type of pulsed welding power source, type of wire feeder, gun and accessories utilized.

*   *   *   *   *   *   *

5086 H-32 ALUMINUM ALLOY SHEET; .063 & .100 INCH THICKNESSES; AIRCO PA-3A/AHF-NP WIRE FEEDER/AH 35-C2 GUN; ER 5356 ALUMINUM ALLOY FILLER WIRE

As stated previously in the text, preliminary welding tests were initiated with use of the Airco PA-3A welding power source, AHF-NP wire feeder and AH 35-C2 manual GMAW gun. With the use of .035 inch diameter 5356 aluminum alloy filler wire it was not possible to get radiographically acceptable welds in the overhead welding position, i.e. Class 1 per NAVSHIPS 0900-003-9000, "Radiographic Standards for Production and Repair Welds."

On .10 inch thick 5086 H-32 aluminum alloy sheet using .035 inch diameter 5356 aluminum alloy filler material the vertical and horizontal specimens welded in the pulse spray mode using Airco PA-3A power supply, AHF-NP feeder and C-2 gun were not acceptable per radiographic testing. Using the PA-3A power supply in the pulse spray mode, it appears that overhead welding is difficult.

Acceptable Weld reinforcements on the second side was not achieyed with use of the Airco PA-3A, 120 pulses per second, spray arc type transfer mode. The overhead weld reinforcement shape in .10 inch material thickness was not acceptable because of an incipient melting condition adjacent to the edges. This caused a discrepancy appearing similar to that of an undercut with the weld deposit being thinner than the base material thickness. Gravity appeared to disrupt the surface tension of the weld puddle causing the molten puddle to drop.

In the overhead position, meeting NAVSHIPS 0900-003-9000, Classl type procedure qualifications requirements for radiographic acceptance was difficult. However, there appears to be no problem meeting Class 3, production welding acceptance standards. Acceptable radiographic production quality level welds could be attained on a consistent and reliable basis.

* * * * * * *

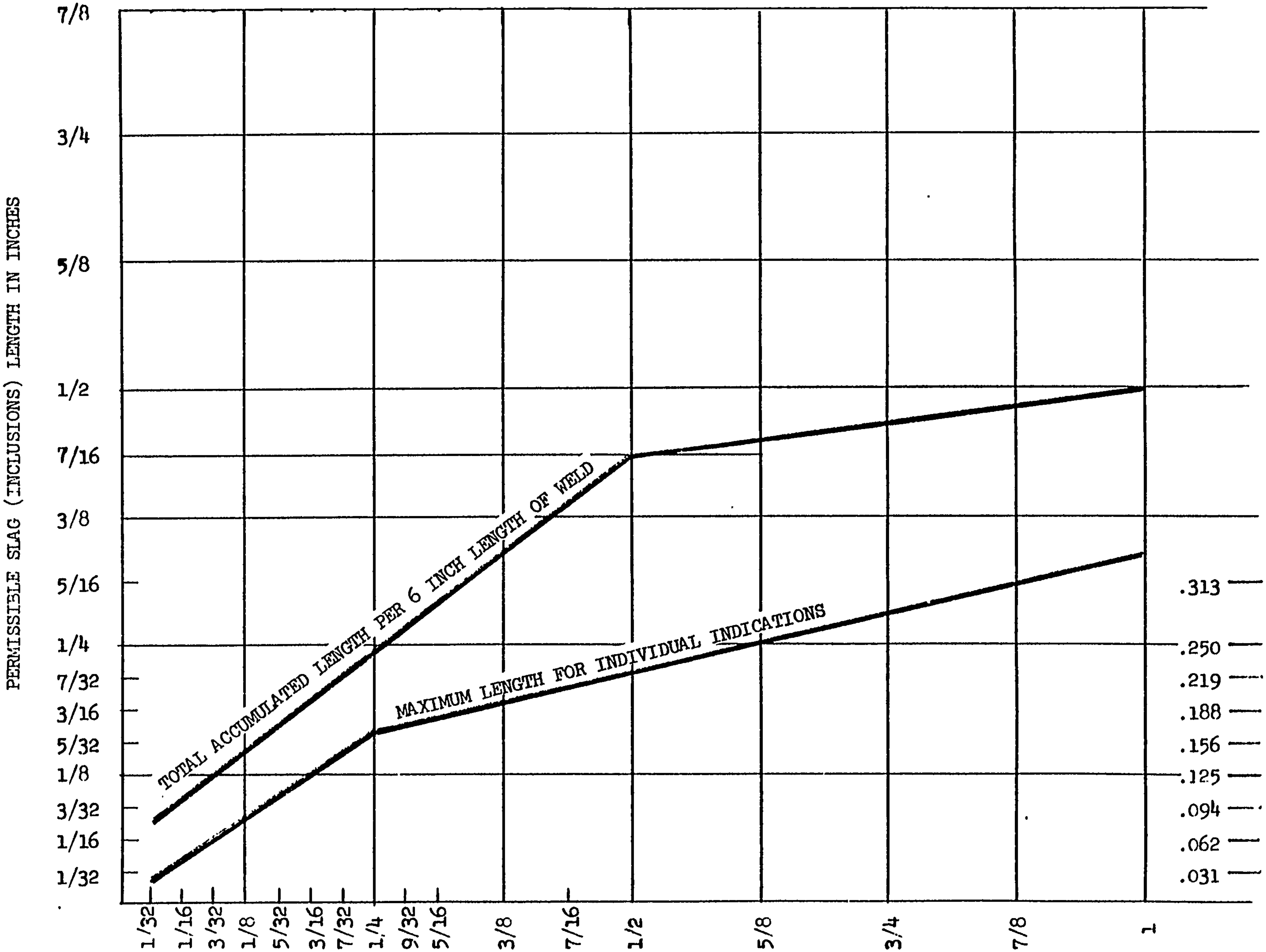
Because of the difficulty in meeting the radiographic requirements for Class 1, permissible length of slag (inclusions) in inches per the requirements of NAVSHIPS 0900-003-9000, a more realistic acceptance criteria for thinner sheet and plate in the 5000 series aluminum alloys appears necessary.

It was concluded that NAYSHIPS 0900-003-9000 is lacking in a clear acceptance definition for material thicknesses below 1/2 (one-half) inch for Class 1 and below 1/4 (one-fourth) inch thicknesses for Class 3, slag (inclusions) radiographic. The curves for both charts have been extrapolated to the left as accurately as feasible in an attempt to show better details in the areas for material thickness less than 1/2 inch for Class 1 and also 1/4 inch for Class 3. Figures 40 and 41 illustrate the curves extended to the left to cover acceptance limits for thinner materials.

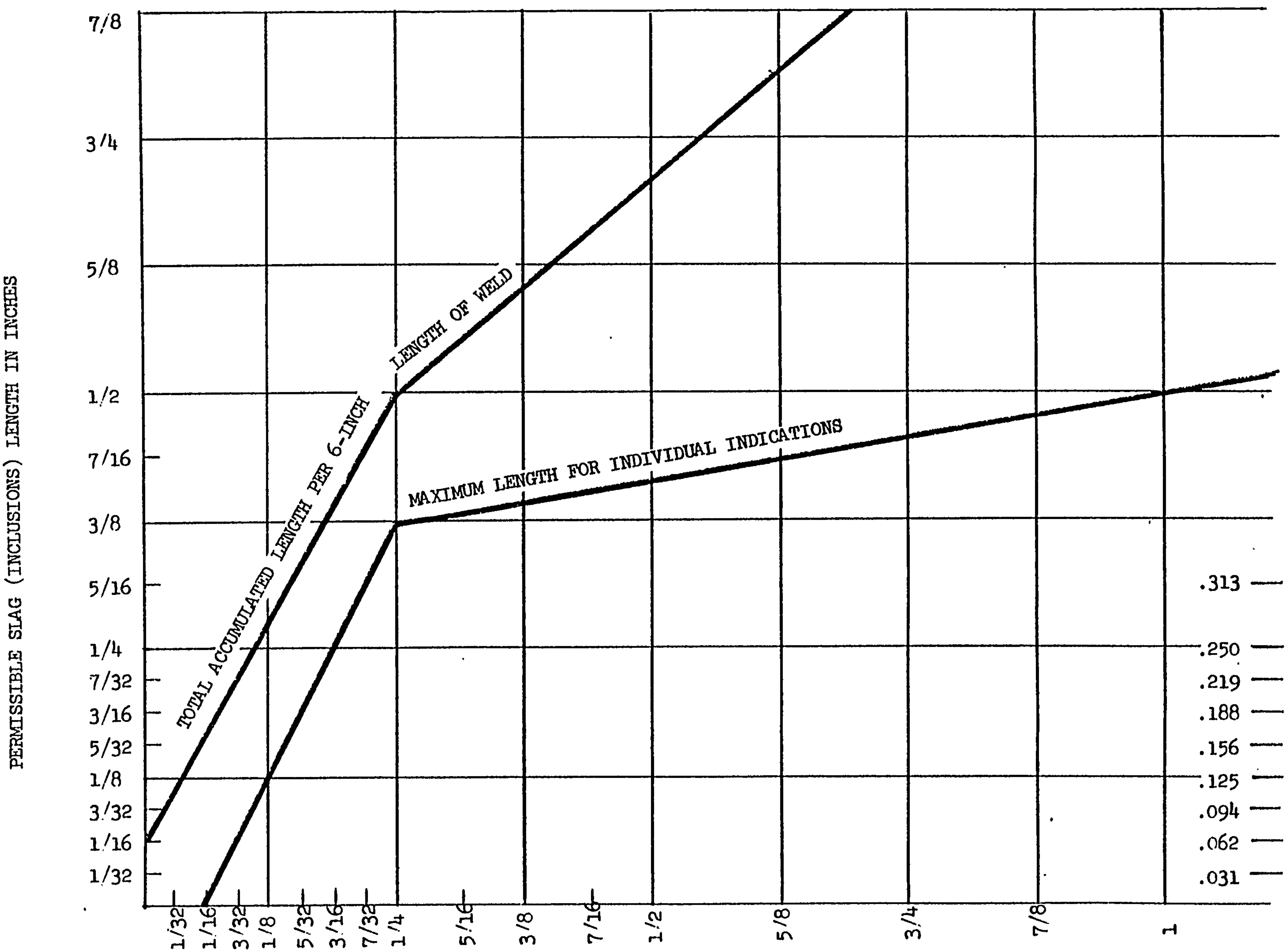
Further comparisons on acceptance standards for slag or inclusions of the American Bureau of Shipping (ABS) and NAVSHIPS 0900-003-9000 were drawn. The curves for the accumulated slag or inclusion appears identical for both. standards. However, the ABS curve for a single inclusion differs somewhat and appears more liberal above 3/4 inch thick plate. See Figure 42.

Considerable difference is illustrated in Figure 43 which compares the ultrasonic acceptance criteria for NAVSHIPS 0900-006-3010, Class 3 and ABS Class B. The maximum length of indications with signals exceeding The ARL (Amplitude Reject Level) is identical for both systems. The NAVSHIPS acceptance is more liberal above 1.75 inches for single indications and above 1.87 inches for accumulated indications.

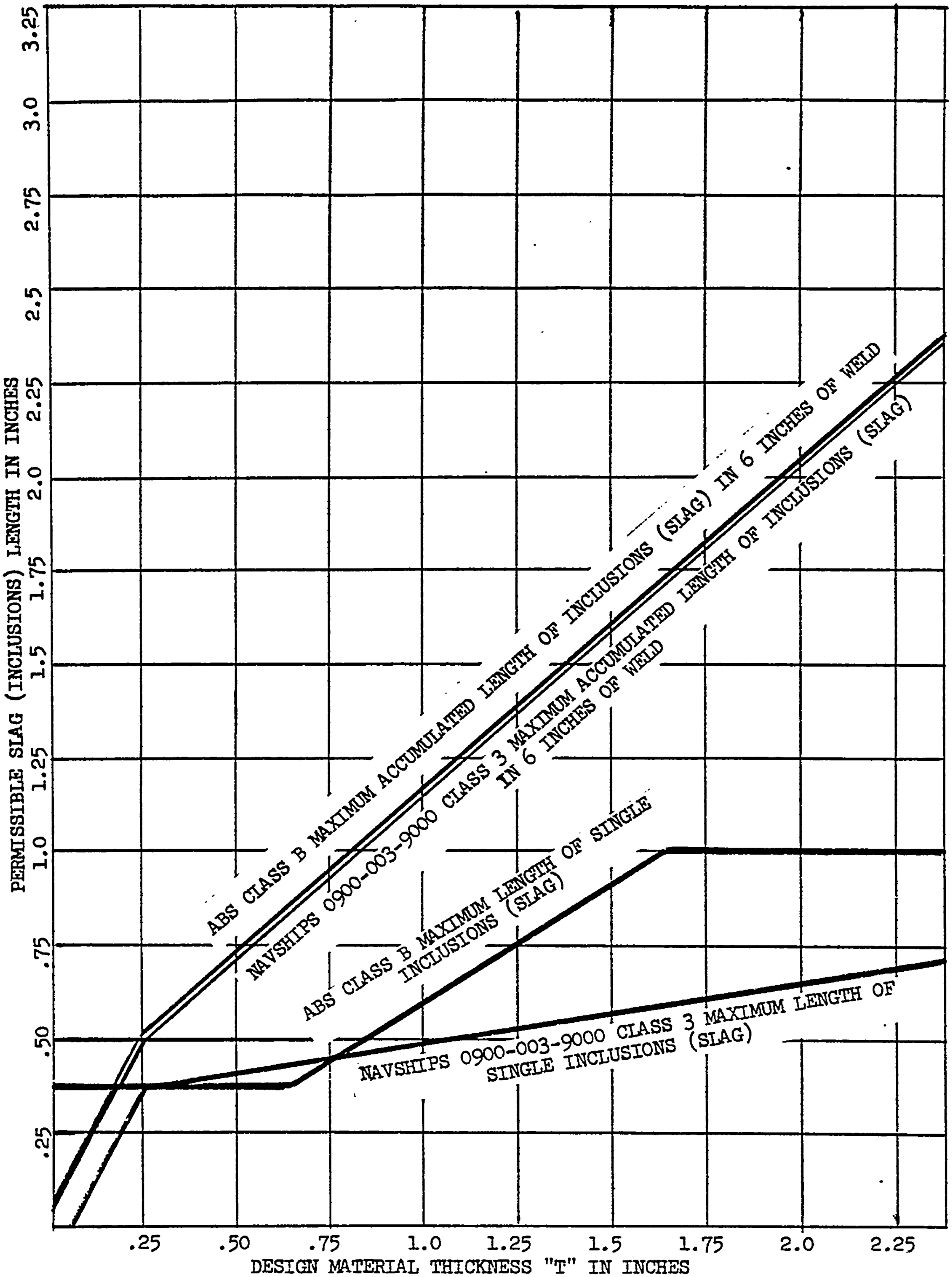
MIL-T-5021, "Tests; Aircraft and Missile Operators Qualification, "stipulates that for materials less than 3/16 inch thick, the maximum allowable defect size is 1/3 the material thickness or .060 inch whichever is less.



DESIGN MATERIAL THICKNESS "T" IN INCHES
NAVSHIPS 0900-003-9000 - CLASS I SLAG (INCLUSIONS)
FIGURE 40

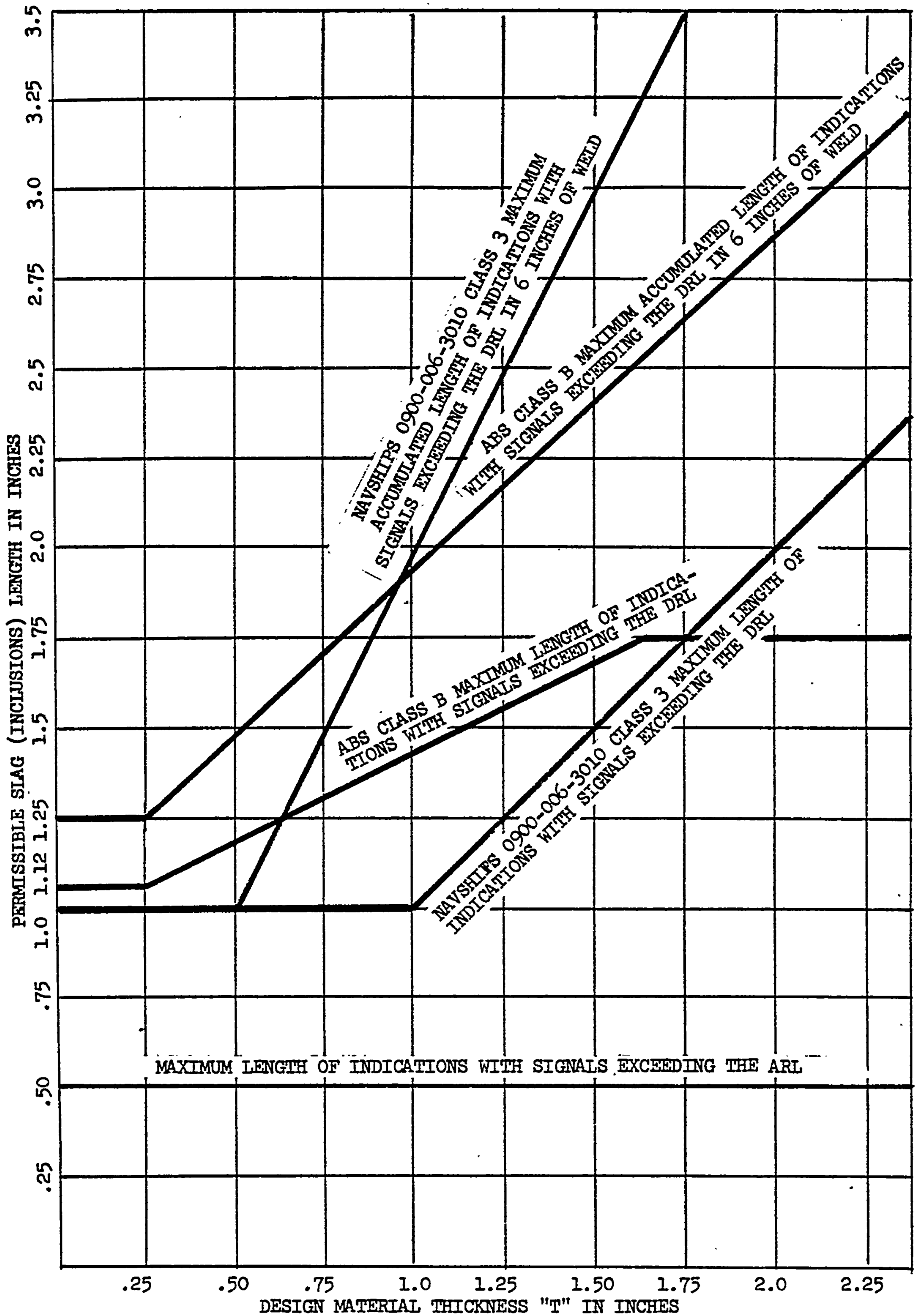


DESIGN MATERIAL THICKNESS "T" IN INCHES
NAVSHIPS 0900-003-9000 - CLASS 3 SLAG (INCLUSIONS)
FIGURE 41



RADIOGRAPHIC INSPECTION OF HULL AND STRUCTURAL WELDING

FIGURE 42



ULTRASONIC INSPECTION OF HULL AND STRUCTURAL WELDING

The Weld Quality Requirements reads as follows:

4.4 Weld quality requirements.

4.4.1 Weld soundness. Welds shall be free of cracks, incomplete fusion or penetration, overlap, undercut, surface voids and overlapping folds. Porosity shall not exceed the following limitations:

a. Single porosity. The maximum extent of single cavities shall not exceed 1/3 of the thickness of the thinner material ("t") of the joint or .060 inch, whichever is the lesser. Interconnected porosity shall be considered as a single cavity.

b. Scattered porosity. The sum of the areas in any plane of all the cavities contained in any one inch length of weld must not exceed 5 percent of an area in square inches equal to one times the thickness of the parent metal, or when unequal thicknesses are welded the thickness of the thinner material.

c. Linear porosity. The sum of the areas of the radiographic images, of three or more porosity cavities in alignment shall not exceed 2.5 percent of an area equal to one times the thickness of the thinner material welded. The maximum extent of linear porosity shall not exceed 1/3 the parent material thickness or .060 inch (whichever is less) and the width shall not exceed 10 percent of parent material thickness at any point.

4.4.1.1 Inclusions, either tungsten or nonmetallic, shall be subject to the same dimensional limitations defined for scattered or linear porosity. Where both inclusions and porosity are present, the total of their combined lengths shall be within the limitations for porosity.

5086 H-32 ALUMINUM ALLOY SHEET: .100 INCH THICKNESS; ER 5356 ALUMINUM ALLOY FILLER; AIRCO PA-3A/PA-350

One complete set of .100 inch thick 5086 H-32, QQ-A-150/7, aluminum alloy sheet material was butt welded out-of-position with the use of full penetration one-side gas metal arc welding process. Two .100 inch thick 5086 H-32 aluminum alloy sheet material approximately 12 inches long x 8 inches wide were butt welded along the 12 inch length to make a weld test specimen panel of 12 inches wide x 16 inches long. Shielding gas used was 75% helium/25% argon. Flow rates were approximately 40 cu. ft. hr. These test panels were welded in the vertical-up, overhead and horizontal. welding positions. All test panels were radiographed and met requirements for Class 1 per NAVSHIPS 0900-003-9000 and MIL-STD-248C. The Airco PA-350 welding power source, System 1 wire feeder, and the Aircomatic (Binzel) 350 ampere air-cooled gas metal arc welding gun combination was utilized. Filler wire was .045 inch diameter 5356 aluminum alloy.

Typical weld machine settings for the various welding positions were as follows:

WELDING POWER SOURCE	WELDING POSITION	WIRE DIAMETER	AMPERES	VOLTAGE	INCHES PER MINUTE
AIRCO PA-3A PULSE MODE	VERTICAL-UP	.030″	45	19	15.6
AIRCO PA-3A PULSE MODE	HORIZONTAL	.035″	55	19	18
AIRCO PA-350 SHORT-ARC MODE	OVERHEAD	3/64″	70	16	17

It should be pointed out that in this set of test specimens, the vertical-up and also the horizontal welding positions were welded with .030 and .035 inch diameter filler wires respectively with the use of the Airco PA-3A welding power source, Airco AHF-NP wire feeder and AH35 C-2 pull gun. Porosity was a problem and therefore weld filler wire diameters were changed to determine whether or not filler wire diameters might have been the cause. It appears that turning off the water in the water coolant system to the torch was the main resolution for the porosity problem when welding at low heat inputs. We decided to omit water recirculation in the water cooled torches for aluminum material thickness under .100 inch. At this point in the program, the Airco PA-3A power source malfunctioned and was sent back to the distributor for repairs and recalibration. All base line data and information was conducted with the use of the Airco 350 welding power source, System 1 wire feeder and the 350 ampere air cooled gun.

As illustrated in the above machine setting chart, the overhead panel was welded with the Airco 350 power source, System 1 wire feeder and 350 ampere Binzel (Aircomatic) air cooled GMAW torch.

Typical weld test set-up for vertical-up, overhead and horizontal positions are shown in Figures 44, 45, 46, and 47. Also, typical weld beads rejected either by visual or by radiography were sheared off approximately 1½ inches wide as illustrated in Figure 48.

* * * * * * *

Shortly after the decision to conduct our base line test development with the Airco PA-350/System 1 feeder/Binzel 2 position air cooled gun combination; at the 64th AWS Annual Convention held in Philadelphia during April 25-29, 1983; a paper entitled, "Study of Droplet Transfer in Pulsed GMAW Welding," was presented by S. Ueguri, K. Hara and H. Komura of Mitsubishi Electric Corporation, Japan. They claimed to have developed a pulsed GMA Welding machine in which the pulsed current is properly stabilized by feedback control of arc voltage. They further claimed that they had determined the required conditions for a proper current waveform by the pulse amplitude, the pulse duration and the pulse frequency, in which small droplet transfer from the wire to base material was attained with great consistency and reliability. And also that a stable arc and spatter free welding condition are achieved.

The key results of their study are quoted below:

"1. During the intitial part of the pulse duration including the base current period, the electrode tip is melted into the droplet. At the end of this part, the volume of pendant droplet at the tip is just so much that the gravity reinforced by the pinch effect overcomes the surface tension, and the droplet begins to move towards the base metal; then the temperature of droplet is at about its melting point, i.e. (1535°c)."

"2. The residual part of the pulse is necessary for the droplet to continue to move and detach finally from the electrode, Thus, the droplet is forced to be superheated up to about 2200°C."

"3. The pulse duration must be just long enough so that the droplet may be heated, transferred and detached from the electrode. And under this condition, the pulse frequency has to be set enough that the electrode melting rate may be equal to the electrode feeding rate. When the duration is much smaller, the droplet fails to transfer to the base metal during one pulse and swells into a large globe which makes an arc unstable. When the duration is longer than necessary, the electrode tip is so much prolonged that the second or third droplet transfers from the wire during one pulse. In this case, the electrode tip is apt to touch the base metal causing much spatter."

"4. In the case of the spray transfer under the steady direct current, the arc heat is continuously put into the wire and the wire tip is prolonged inevitably. On the other hand, we can get a shorter and stabler arc by a proper pulsed current described above.”

"5. We calculated the profile of pendant droplet according to Greene's theory and found a good agreement between the calculated results and the experimental results observed with high-speed motion picture. Greene's theory has been developed for the steady direct current and not yet verified by any experiment. However, in the case of mild steel and stainless steel, we consider his theory is more suited for the pulsed current, since his assumption that the shape of pendant droplet is globular is more appropriately satisfied with batch input."

*   *   *   *   *   *   *

Discussions previously with Mitsubishi Electric personnel at the AWS (American Welding Society) Welding Shows indicated that their pulse arc GMAW power surce was not recommended for welding aluminum or aluminum alloy materials.

The Airco PA-350 pulse arc welding power source does have capabilities to weld aluminum and aluminum alloys in addition to welding mild steel, stainless steel and other materials. The Airco PA–350 appears to conform very much to Messrs. S. Ueguri, et. al.'s description of a pulsed GMAW power source in which, "pulsed current is properly stabilized by feed-back control of arc voltage."

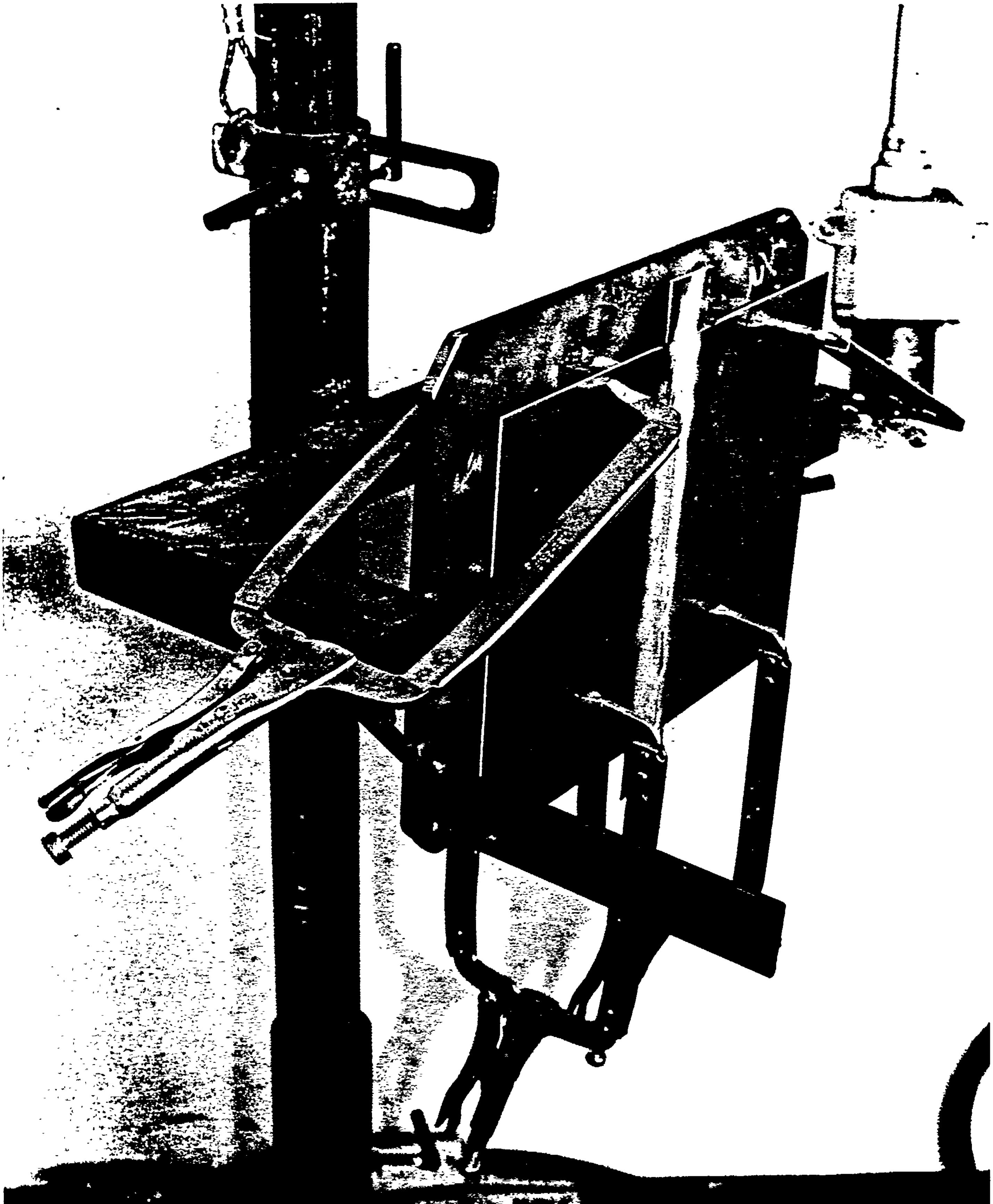


FIGURE 44
TYPICAL WELD TEST SET-UP FOR VERTICAL-UP WELDING

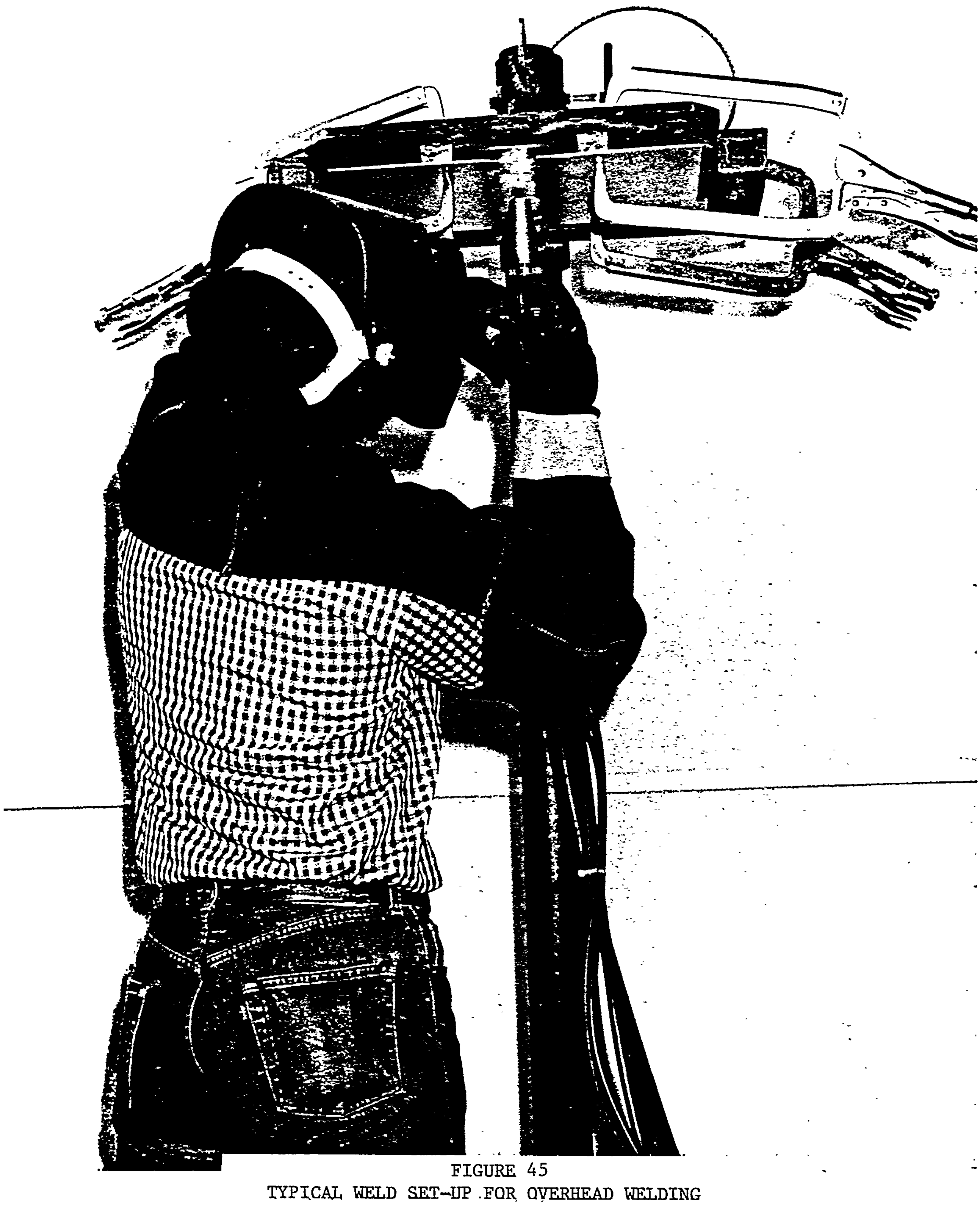


FIGURE 45
TYPICAL WELD SET-UP FOR OVERHEAD WELDING

FIGURE 46
TYPICAL WELD SETTING DEVELOPMENT APPROACH FOR HORIZONTAL WELD: FULL PENETRATION BUTT WELD

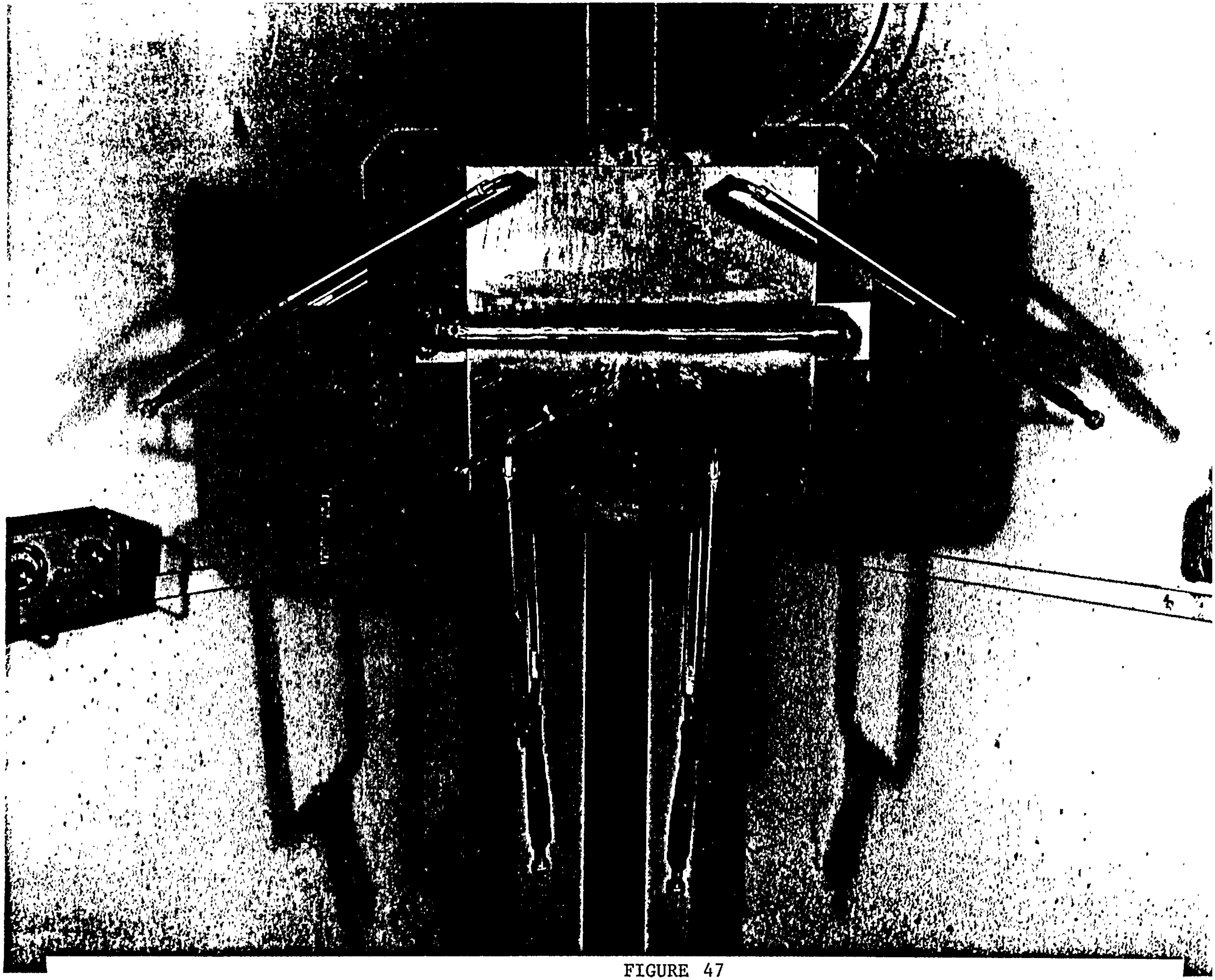


FIGURE 47

TYPICAL COMPLETED TEST PANEL WELDED IN HORIZONTAL POSITION; ONE PASS, FULL PENETRATION

FIGURE 48

TYPICAL REJECTED WELD BEADS (VIA VISUAL/RADIOGRAPHIC INSPECTIONS)
SHEARED/MACHINED OFF TEST PANEL

CRUTCHER RESOURCES CORPORATION (CRC)
ARC DATA ANALYZER (ADA)

An arc data analyzer was procured from CRC Welding Systems; Houston, Texas to monitor and record our basic welding variables during the establishment of certified weld machine settings. See Figure 49.

The ADA thermal printout provides extensive welding information about each weld. Every log is prefaced with the date, time, welding station and the test number. The ADA prints the welding parameter values at a frequency selected by the user. In addition to printing the average values for arc voltage and current, the ADA computes and prints the standard deviation for these parameters. The standard deviation provides a statistical measure of the variation of voltage and current signals about their average values.

Upon completion of a weld, a printed summary showing total elapsed arc-on time, travel distance, length of filler wire used, total deposition and heat input is made available.

A typical thermal printout illustrating the data log is illustrated in Figure 50.

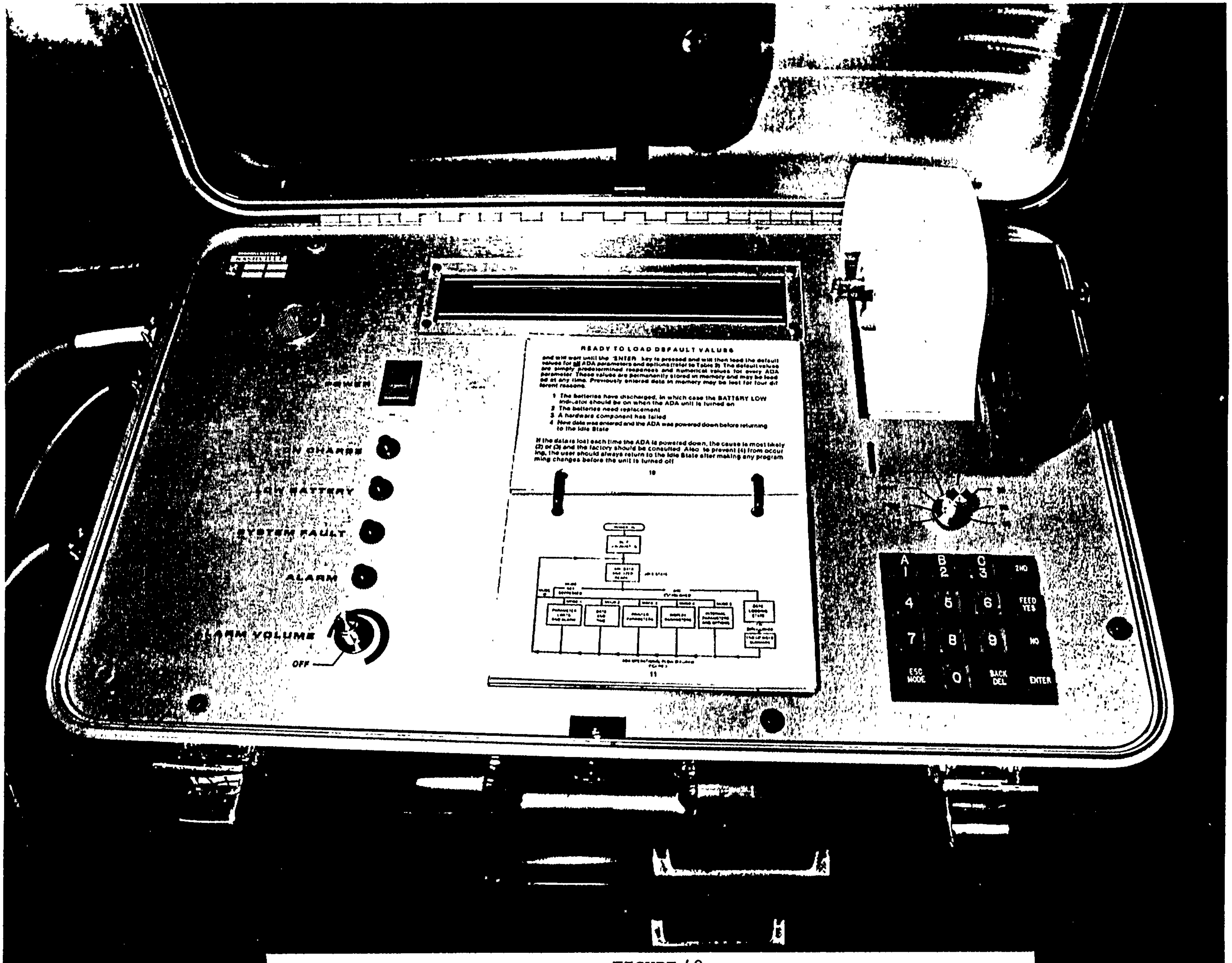

READY TO LOAD DEFAULT VALUES
SYSTEM FAULT
ALARM
OFF
A 1
B 2
C 3
4
5
6
FEED YES
7
8
9
NO
ESC MODE
0
BACK DEL
ENTER

FIGURE 49

```
DATE                          05-31-83 09:56:55 AM        TIME
WELDING LAB                   STATION 0001     #034       TEST NUMBER
                              DC VOL AND CUR
                                                          VOLTAGE
ELAPSED TIME                  ETM     CUR      VOL        WELDING CURRENT
POWER                         PWR     WSP      DPR        DEPOSITION RATE
WIRE FEED SPEED                                           WELDING CURRENT
INTERVAL READOUTS (TYPICAL)   00:08    097.     17.0      WELDING VOLTAGE
FOUR SECOND                   01.61    269.     02.5

                              00:12    096.     16.7
                              01.56    270.     02.5

                              00:16    097.     16.9
                              01.59    270.     02.5

                              00:20    096.     16.9
                              01.59    269.     02.5

                              00:24    096.     16.9
                              01.58    270.     02.5

                              00:28    097.     16.8
                              01.59    269.     02.5

                              00:32    094.     17.0
                              01.55    270.     02.5

                              00:36    096.     16.8
                              01.58    270.     02.5

                              00:40    096.     17.0
                              01.57    270.     02.5

                              00:44    095.     16.8
                              01.56    270.     02.5

                              WELD SUMMARY

                              ELAPSED TIME   00:45
                              TRAVEL DIST 0013.5IN
                              WIRE       000201.8IN
                              HEAT INPUT   00068KJ
                              DEPOSITION   000.0LB

                              OUT OF LIMIT SUMMARY

                              DPR     HI   00:04
```

FIGURE 50

CRC ARC DATA ANALYZER
DISPLAY OF
WELDING VARIABLES

5086 H-32 ALUMINUM ALLOY SHEET: .063 INCH THICKNESS; ER 5556 ALUMINUM ALLOY FILLER WIRE; AIRCO PA-350

One set of .063 inch thick 5086 H-32, QQ-A-150/7, aluminum alloy sheet material was butt welded out-of-position with the use of the full penetration one-side gas metal arc welding process. Two 1/16 inch thick x 8 inch wide x 12 inch long sheets were butt welded to make an approximately 12 inch x 16 inch test panel. See Figure 51, which shows the weld bead surface and underbead. These weld test panels were subsequently machined into mechanical properties specimens. i.e. Tensiles, root and face bend specimens. Start and stop tabs approximately 2 inches x 1 inch x .063 inch thickness of same aluminum alloy as the base materials were used so that maximum panel length could be used. Shielding gas used was 75% helium/25% argon. These test panels were welded in the vertical-up, overhead and horizontal welding positions. No flat (downhand) panels were welded because these are normally not required for welding procedure qualification. All test panels were radtographed and met Class 1 requirements per NAVSHIPS 0900-003-9000 and MIL-STD-248C. The Airco PA-350 welding power source, System 1 wire feeder and Aircomatic (Binzel) 350 ampere air-cooled gas metal arc gun was utilized. Filler wire was 3/64 inch diameter, 5556 aluminum alloy. Typical machine settings for the various welding positions are as follows:

WELDING POSITION	WIRE DIAMETER	AMPERE	VOLTAGE	TRAVEL SPEED INCHES PER MINUTE	ALUMINUM ALLOY FILLER WIRE
VERTICAL-UP	3/64 inch	50	15	18	ER 5556
OVERHEAD	3/64 inch	50	15.5	20	ER 5556
HORIZONTAL	3/64 inch	50	15	18	ER 5556

Specific pertinent machine settings that were used on test panels are covered later in the section covering weld machine settings.

Figures 52, 53, and 54 show the typical weld bead surfaces and also the penetration bead on the far side.

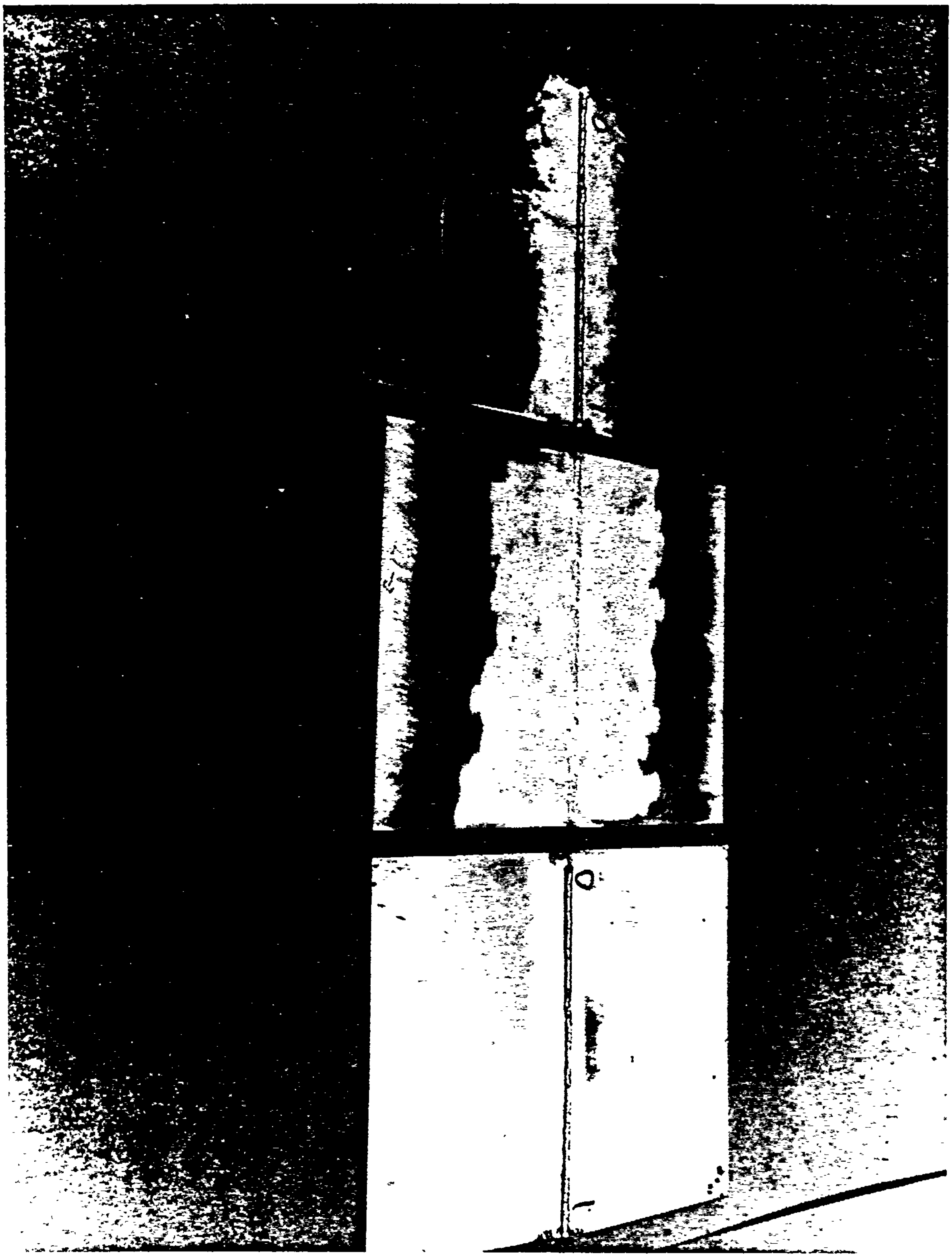


FIGURE 51

5086 H-32 ALUMINUM ALLOY SHEET 0.063 INCH THICK WELD TEST PANELS;
WELD BEAD SURFACE (CENTER)/WELD BEAD UNDER BEAD (TOP/BOTTOM)

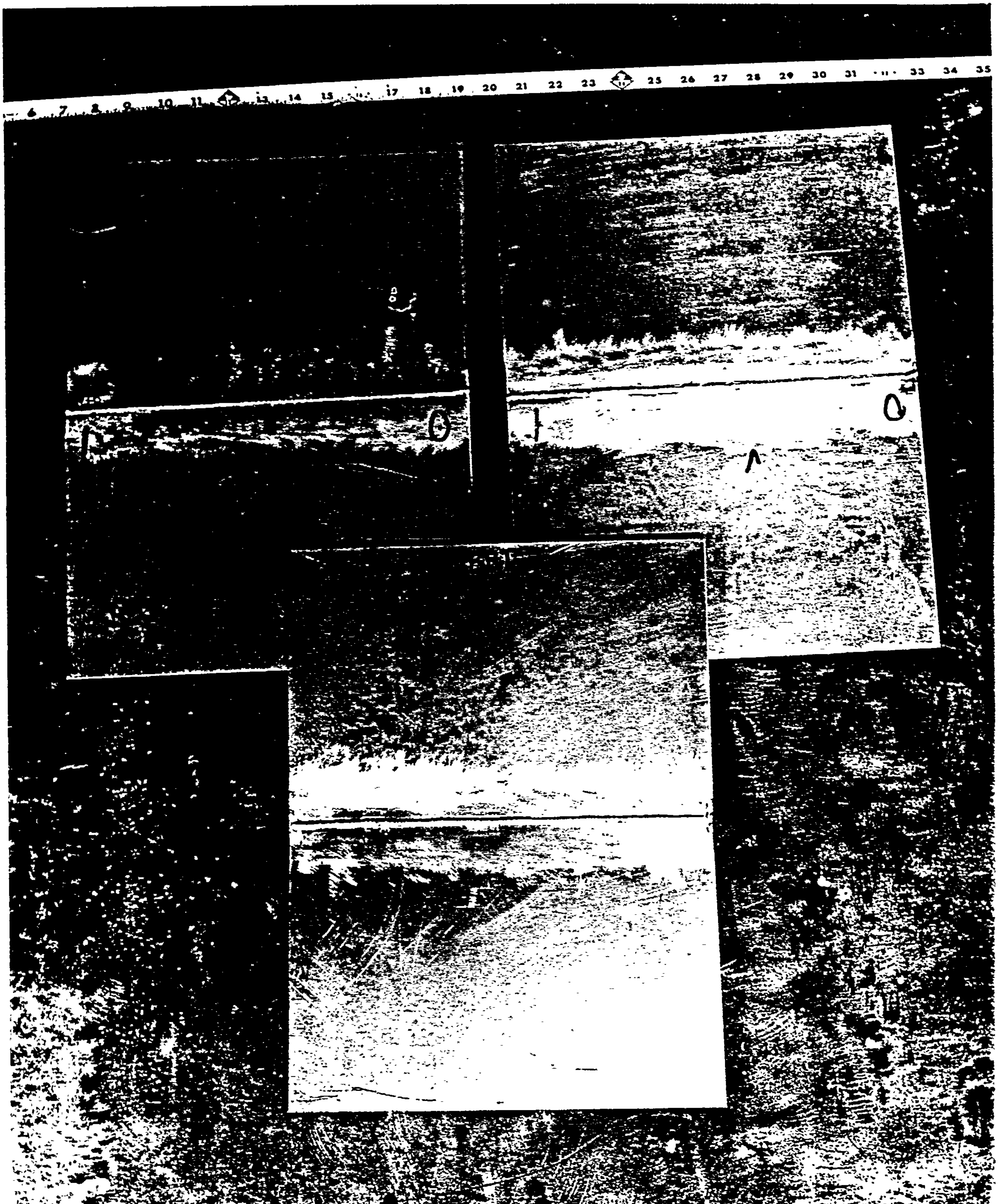


FIGURE 52
TYPICAL VERTICAL-UP WELD BEAD SURFACES (TOP LEFT & RIGHT) AND BACK WELD BEAD (BOTTOM)

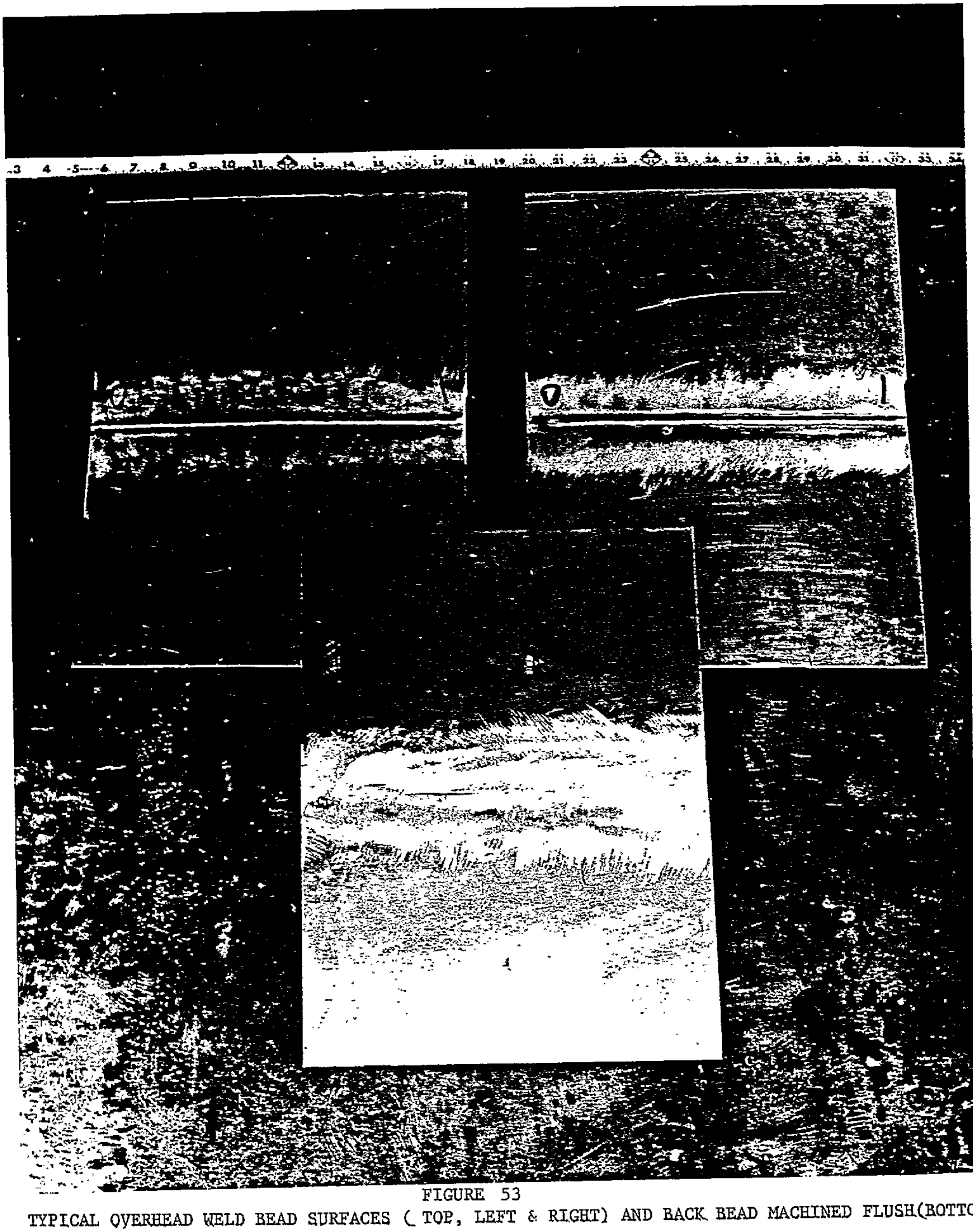


FIGURE 53
TYPICAL OVERHEAD WELD BEAD SURFACES (TOP, LEFT & RIGHT) AND BACK BEAD MACHINED FLUSH(BOTTOM

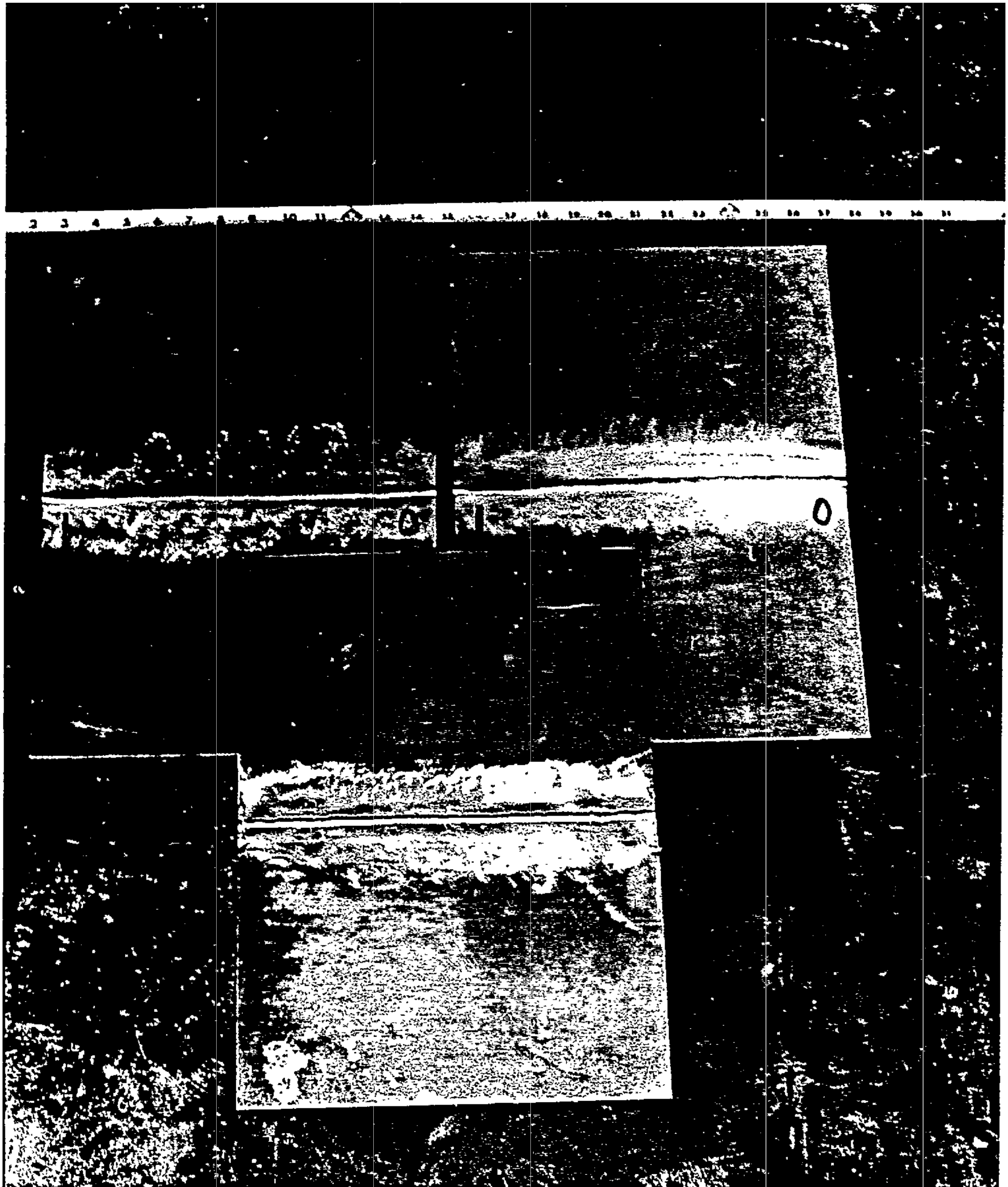


FIGURE 54
TYPICAL HORIZONTAL WELD BEAD SURFACES (TOP, LEFT & RIGHT) AND BACK BEAD (BOTTOM)

5086 H-32 ALUMINIUM ALLOY SHEET: .063 INCH THICKNESS;
ER 5356 ALUMINUM ALLOY FILLER WIRE; AIRCO PA-350

Two pieces of 7½ inch wide x 12 inch long were butt welded with the gas metal arc welding process in the vertical-up position to make a 15 inch x 12 inch butt welded panel. Aluminum alloy filler wire used was 3/64 inch diameter 5356 aluminum alloy. The welding was accomplished in the short-arc mode on the Airco 350 power source, System 1 wire feeder and Aircomatic 350 ampere (Binzel) GMAW torch combination.

For some unknown reason it was not possible to attain Class 1 radiograph quality level butt welds in either the overhead or horizontal positions. Why it was feasible to weld in all positions with the use of 3/64 inch diameter 5556 aluminum alloy filler wire and not with the use of 5356 aluminum alloy wire was unknown at this point in time.

Typical machine settings for vertical-up welding were as follows:

WELDING POSITION	WIRE DIAMETER	AMPERES	VOLTAGE	TRAVEL SPEED INCHES PER MINUTE
VERTICAL-UP	3/64 INCH	40	15.5	18.5

5083 H-323 ALUMINUM ALLOY SHEET: .125 INCH THICKNESS:
ER 5356 ALUMINUM ALLOY FILLER WIRE; AIRCO PA-350

Out-of-position full penetration gas metal arc butt welding of .125 inch thick 5083 H-323, QQ-A-250/6, aluminum alloy sheet base material was completed. Two base metal plates each .125 inch thick x 8 inches wide x 12 inches. long were butt welded to make mechanical properties specimen test panels 12 inches x 16 inches. All test panels welded were radiographed to meet Class 1 requirements per NAVSHIPS 0900-003-9000 and MIL-STD-248C. The Airco PA-350 welding power source, System 1 wire feeder and Airco-matic (Binzel) 350 ampere air-cooled gas metal arc welding gun equipment combination was used. Typical short-arc welding machine settings for the various welding position and filler wire alloy and diameters are shown below:

FILLER WIRE ALLOY & DIAMETER	WELDING POSITION'	AMPERES	VOLTAGE	TRAVEL SPEED INCHES PER MINUTE
ER 5356 3/64" dia.	VERTICAL-UP	70	17	14.1
ER 5556 3/64" dia.	VERTICAL-UP	70	17	12.8
ER 5556 3/64" dia.	HORIZONTAL	85	19.5	1.5
ER 5356 3/64" dia.	OVERHEAD	105	15	20

Out-of-position, one-side, full penetration manual pulsed GMAW butt welded test panels were etched in the weld cross sectional areas and visually inspected with 10X magnification. The etching reagent used for revealing the microstructure on the 5000 series aluminum test panels is listed below.

ETCHANT FOR ALUMINUM AND ALUMINUM ALLOYS	
Hydrochloric Acid (Cone.)	15 ml.
Hydrofluoric Acid (48%)	10 ml.
Water	85 ml.

This solution was used at room temperature and applied on the prepared weld cross sectional area by swabbing.

The weld *cross* sectional surface areas were prepared by filing and sanding with metallographic paper. The etchant solution was swabbed on with cotton applicators until the desired contrast was attained. Upon etching, the test panel specimens were rinsed thoroughly and dried with warm air.

Typical etched weld cross sectional areas for .063 - .250 inch weld test panels are illustrated in Figure 55.

FIGURE 55
TYPICAL OUT-OF-POSITION, ONE-SIDE FULL PENETRATION MANUAL PULSED GMAW BUTT WELD CROSS SECTIONS (ETCHED)

5086 H-116 ALUMINUM ALLOY PLATE: .250 INCH THICKNESS; ER 5556 ALUMINUM-ALLOY FILLER WIRE; AIRCO PA-350

One set each of 1/4 inch thick, 5086 H-116, QQ-A-150/19, aluminum alloy plate materials were butt welded in the vertical-up and horizontal welding position. Two 1/4 inch thick x 8 inch wide x 12 inch long test piece parts were butt welded to make a 12 x 16 inch weld test panel. Both vertical-up and horizontal test panels were acceptable radiographically. However, acceptable overhead panels could not be attained per Class 1 requirements of NAVSHIPS 0900-003-9000. The Airco PA-350 welding power source, System 1 feeder, and the Binzel 350 ampere air-cooled torch set-up was used. Filler wire was ER 5556 aluminum alloy in the 3/64 inch diameter size. Typical machine settings for the vertical-up and the horizontal positions are summarized below:

WELDING POSITION	WIRE DIAMETER	AMPERE	VOLTAGE	TRAVEL SPEED INCHES-PER-MINUTE.	ALUMINUM ALLOY FILLER WIRE
VERTICAL-UP	3/64"	150	16	11.5	ER 5556
HORIZONTAL	3/64"	149	14.5	8.4	ER 5556

For specific details, see following section on machine settings.

At a later date when developing radiographically acceptable weld machine settings, successful welds in the overhead position ora .250 inch. thick, 5086 H-116 aluminum alloy plates were attained with the use of 3/64 inch diameter 5356 aluminum alloy filler wire.

5456 H-116 ALUMINUM ALLOY PLATE: .250 INCH THICKNESS
ER 5556 ALUMINUM ALLOY FILLER WIRE; AIRCO PA-350

One set each of 1/4 inch thick, 5456 H-116 aluminum alloy, QQ-A-150/20, plate materials were butt welded out-of-position in the vertical-up and horizontal positions. Two 1/4 inch thick x 8 inch wide x 12 inch long test piece parts were butt welded to make a 12 x 16 inch weld test panel. All test panels were acceptable when non-destructive tested, i.e. visual, penetrant, and radiographic. Full penetration, one-side welds in the overhead position could not be achieved. The Airco PA-350 welding power source, System 1 feeder and the Binzel 350 ampere air-cooled torch set-up was utilized. Filler wire was 3/64 inch diameter, ER 5556 aluminum alloy. Typical machine settings for the vertical-up and horizontal positions are summarized below:

WELDING POSITION	WIRE DIAMETER	AMPERE	VOLTAGE	TRAVEL SPEED INCHES-PER-MINUTE	ALUMINUM ALLOY FILLER WIRE
VERTICAL-UP	3/64″	115	18	9.3	ER 5556
HORIZONTAL	3/64″	156	14.5	8.5	ER 5556

For specific pertinent details, see section on Machine Settings.

At a much later date when developing radiographically acceptable weld machine settings, successful welds in the overhead position on .250 inch thick, 5456 H-116 aluminum *alloy* plates were attained with the use of 3/64 inch diameter, 5356 aluminum alloy filler wires.

5083 H-321 ALUMINUM ALLOY PLATE: .250 INCH THICKNESS; ER 5556 ALUMINUM ALLOY FILLER WIRE; AIRCO PA-350

One set each of 1/4 inch thick, 5083 H-321 aluminum alloy, QQ-A-150/6, plate materials were butt welded in the vertical-up and horizontal positions. Two 1/4 inch thick x 8 inch wide x 12 inch long test piece parts were butt welded to make a 12 x 16 inch weld test panel. All test panels passed visual, penetrant and radiographic inspection requirements. Full penetration, one-side welds in the overhead position could not be attained. The Airco PA-350 welding power source, System 1 feeder and Binzel 350 ampere air-cooled torch welding set-up was utilized. Filler wire used was 3/64 inch diameter, ER 5556 aluminum alloy. The typical machine settings for the vertical-up and horizontal welding positions are summarized below:

WELDING POSITION	WIRE DIAMETER	AMPERE	VOLTAGE	TRAVEL SPEED INCHES PER MINUTE	ALUMINUM ALLOY FILLER WIRE
VERTICAL-UP	3/64″	130	15.7	12	ER 5556
HORIZONTAL	3/64″	145	14.5	10.2	ER 5556

For more detailed information, see section on Machine Settings.

At a much later date when developing radiographically acceptable weld machine settings, successful welds in the overhead position on .250 inch thick, 5083 H-321 aluminum alloy plates were attained with the use of 3/64 inch diameter, 5356 aluminum alloy filler wires.

WELDING PROCEDURE SPECIFICATION QUALIFICATION DATA

Weld procedure qualification test summary pages covering the necessary welding parameters such as base material, filler wire type and diameters, shielding gas(es), pulse power source, torch, cup orifice, welding position, preheat, current characteristics, current range, voltage range, wire feed speeds, travel speed and non-destructive test results are shown in the following pages. Specific weld machine settings as well as mechanical properties data are covered under respective sections in this report.

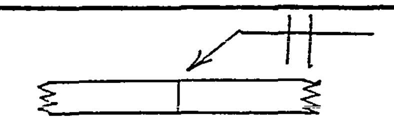
TODD

PACIFIC SHIPYARDS CORPORATION

SEATTLE DIVISION

WELDING PROCEDURE QUALIFICATION TEST SUMMARY

TEST SERIES NO. A1.3
PROCEDURE NO. ______
PROCESS GMAW
CONTRACT MARAD SP-7
DATE 12/1/83



QUALIFICATION JOINT

MATERIALS:
BASE SPEC. QQ-A-150/7 5086 H-32
MATL. THICKNESS .063"
FILLER SPEC. AWS A5.10-80 ER 5556
FILLER DIA. 3/64"
SHIELDING GAS 75%HE/25%AR
FLUX AND SIZE NA
EQUIPMENT:
POWER SUPPLY AIRCO PULSE ARC 350
TORCH OR HOLDER TYPE BINZEL
CUP TYPE & SIZE 3/4" METALLIC
ELECTRODE TYPE & SIZE NA

OPERATING PARAMETERS:
WELDING POS. VERT-UP NO. PASSES 1
PREHEAT 60° MIN INTERPASS TEMP. ______
CURRENT CHARAC. D.C. R.P.
CURRENT RANGE 50
VOLTAGE RANGE 15
WIRE FEED IPM 125
SHIELD FLOW 40 CFH
TRAVEL SPEED 18 IPM
MAX. HEAT INPUT J/IN NA
HEAT TREAT NA
OTHER ______

NDT TESTS:

[x] VIS. [x] PT [ ] UT [x] RT [ ] MT

DT TESTS:

	DT TESTS	PLATE OR SPEC. SER. NO.
X	RST	Sat. Report # E28426-2
	HRDNS	
	CHARPY	
	SIDE BEND	
X	ROOT BEND	Sat. Report # E28426-2
X	FACE BEND	Sat. Report # E28426-2
	FILLET BEND	
	FILLET BREAK	
	TRANS. SHEAR	
	LONG SHEAR	
	EXPL. BULGE	
	OTHER	

RESULTS:
Visual - No visible defects
P.T. Acceptable - Report # 1609 attached
R.T. Acceptable - Report # 7039 attached

REMARKS: ______

J.H. HITCH *J H Hitch*	10879	J. JOHNSTON	
WELD OPR.	CLOCK NO.	TEST BY	QUAL. RANGE

THIS CERTIFIES THAT THE DATA HEREIN IS COMPLETE AND ACCURATE TO BEST POSSIBLE KNOWLEDGE AND THAT TESTING AND EVALUATION WAS CONDUCTED IN ACCORDANCE WITH THE REQUIREMENTS LISTED BELOW.

James C Johnston
WELDING ENGINEER DATE

TODD SHIPYARDS CORPORATION
SEATTLE DIVISION
QUALITY ASSURANCE DEPARTMENT

DATE 5-10-83

TODD ORDER NO. 4787 ITEM NO. 101.00 REPORT NO. 1609

DYE PENETRANT NONDESTRUCTIVE TEST REPORT

JOB DESCRIPTION

MARAD PLATE GMAW SHORT ARC PROCESS

FOR: TWPS No. A 1. 3	MATERIAL: Aluminum
PENETRANT EQUIP. DUBL-CHEK; VISIBLE RED	PENETRANT TIME: 15-20 min.
REPORTS TO: Distribution	DEVELOPMENT TIME: 7-30 min.

PER SPEC: MIL-STD-271 E , NAVSHIPS 0900-003-8000, CLASS I

CONTRACT NO. NNS POM 70200-R

Liquid penetrant inspection of weld was found to be acceptable.

PENETRANT INSPECTOR B. Dyer R. Bell

QA-PT-

Cable "Robin" New York

TODD SHIPYARDS CORPORATION

Seattle Division: 1801 16th Avenue, S.W. Seattle, Washington 98124 • 623-1635 (206)

REPORT NO. 7039
DATE 5/9/83
HULL N/A

RADIOGRAPHIC INSPECTION REPORT-WELDMENTS--

CONTRACT NO. NNS POM-70200-R

JOB NAME TWPS No. A 1 . 3 JOB NO. 4787 ITEM NO. 101.00 PAGE 1 of 1

DESCRIPTION MARAD PLATE GMAW SHORT ARC PROCESS MAT'L Aluminum .063 QUANTITY 1

RSS NO. WQ-001-A QUALITY LEVEL: 2-2T ☒ 2-4T ☐ --% RT: 100% ☒ 50% ☐ 10% ☐ SPOT ☐

MIL- STD-271-E ☒
NAVSHIPS 0900-003-9000, CLASS 1
ABS CLASS A ☐ CLASS B ☐
OTHER:

FILM TYPE(S)	SFD (INCHES)	THICKNESS (INCHES)	SEQUENCE NO.	VIEW	ORIG. or REP.	POROSITY	INCLUSIONS	INCOMPLETE PENETRATION	INCOMPLETE FUSION	CRACK	UNDERCUT	SURFACE	OTHER	DISPOSITION: JOINT A 1 . 3	DISPOSITION: ACCEPT	DISPOSITION: REJECT	REMARKS
D-4	30	.063	-	0-1	O	1					1	1	*	VERT UP	X		*Spatter not removed Prior to removal of weld reforcement

CODE
. ACCEPTABLE
. BORDERLINE
. EXCESSIVE

SINGLE FILM ☒
MULTIFILM ☐
BOTH ☐

RADIATION SOURCE:
X-RAY: KV 70 mA 2
IR-192: CURIES

NO. OF VIEWS	FILM SIZE AND QUANTITY: 4½×17	4½×10		
1	2			

PREPARED BY T. Moore

APPROVED BY R. W. Bell

ACCEPTED BY

RADIOGRAPHER(S) T. Moore/C. Krofta

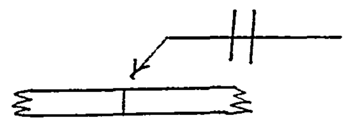
QA-RT-2

TODD PACIFIC SHIPYARDS CORPORATION

SEATTLE DIVISION

WELDING PROCEDURE QUALIFICATION TEST SUMMARY

TEST SERIES NO. A1.23
PROCEDURE NO.
PROCESS GMAW
CONTRACT MARAD SP-7
DATE 12/1/83



QUALIFICATION JOINT

MATERIALS:
BASE SPEC. QQ-A-150/7
5086 H32
MATL. THICKNESS .063"
FILLER SPEC. AWS A5.10-80
ER 5356
FILLER DIA. 3/64"
SHIELDING GAS 75%HE/25%AR
FLUX AND SIZE NA
EQUIPMENT:
POWER SUPPLY AIRCO PA 350
TORCH OR HOLDER TYPE BINZEL
CUP TYPE & SIZE METALLIC 3/4"
ELECTRODE TYPE & SIZE NA

OPERATING PARAMETERS:
WELDING POS. VERT-UP NO. PASSES 1
PREHEAT 60^{O}MIN INTERPASS TEMP.
CURRENT CHARAC. D.C. R.P.
CURRENT RANGE 40
VOLTAGE RANGE 15.5
WIRE FEED IPM 172
SHIELD FLOW 40 CFH
TRAVEL SPEED 18.5 IPM
MAX. HEAT INPUT J/IN NA
HEAT TREAT NA
OTHER

NDT TESTS:

[X] VIS. [X] PT [ ] UT [X] RT [ ] MT

DT TESTS:	PLATE OR SPEC. SER. NO.
[X] RST	Sat. Report # E28426-3
[ ] HRDNS	
[ ] CHARPY	
[ ] SIDE BEND	
[X] ROOT BEND	Sat. Report # E28426-3
[X] FACE BEND	Sat. Report # E28426-3
[ ] FILLET BEND	
[ ] FILLET BREAK	
[ ] TRANS.SHEAR	
[ ] LONG SHEAR	
[ ] EXPL.BULGE	
[ ] OTHER	

RESULTS:
Visual - No visible defects
P.T. Acceptable - Report # 1611 attached
R.T. Acceptable - Report # 7037 attached

REMARKS:

J.H. HITCH	J H Hitch	10879	J. JOHNSTON	
WELD OPR.		CLOCK NO.	TEST BY	QUAL. RANGE

THIS CERTIFIES THAT THE DATA HEREIN IS COMPLETE AND ACCURATE TO BEST POSSIBLE KNOWLEDGE AND THAT TESTING AND EVALUATION WAS CONDUCTED IN ACCORDANCE WITH THE REQUIREMENTS LISTED BELOW.

James C Johnston
WELDING ENGINEER DATE

TODD SHIPYARDS CORPORATION
SEATTLE DIVISION
QUALITY ASSURANCE DEPARTMENT

DATE 5-10-83

TODD ORDER NO. 4787 ITEM NO. 101.00 REPORT NO. 1611

DYE PENETRANT NONDESTRUCTIVE TEST REPORT

JOB DESCRIPTION MARAD PLATE GMAW SHORT ARC PROCESS	
FOR: TWPS NO. A 1 . 23	MATERIAL: Aluminum
PENETRANT EQUIP. DUBL-CHEK; VISIBLE RED	PENETRANT TIME: 15-20-.
REPORTS TO: Distribution	DEVELOPMENT TIME: 7-30 min.
PER SPEC: MIL-STD-271 E , NAVSHIPS 0900-003-8000, CLASS I	

CONTRACT *NO.* NNS FOM 70200-R

Liquid penetrant inspection of weld was found to be acceptable.

PENETRANT INSPECTOR B. Dyer
R. Bell

QA-PT.

Cable "Robin" New York

TODD SHIPYARDS CORPORATION

Seattle Division: 1801 16th Avenue, S.W. Seattle, Washington 98124 • 623-1635 (206)

REPORT NO. 7037
DATE 5/9/83

RADIOGRAPHIC INSPECTION REPORT-WELDMENTS-- CONTRACT NO. NNS POM-70200-R HULL N/A

JOB NAME TWPS No. A 1 . 23 JOB NO. 4787 ITEM NO. 101.00 PAGE 1 of 1

DESCRIPTION MARAD PLATE GMAW SHORT ARC PROCESS MAT'L Aluminum .063 QUANTITY 1

RSS NO. WQ-001-A QUALITY LEVEL: 2-2T ☒ 2-4T ☐ --% RT: 100% ☒ 50% ☐ 10% ☐ SPOT ☐

MIL- STD-271-E ☒
NAVSHIPS 0900-003-9000, CLASS 1
ABS CLASS A ☐ CLASS B ☐
OTHER:

FILM TYPE(S)	SFD (INCHES)	THICKNESS (INCHES)	SEQUENCE NO.	VIEW	ORIG. or REP.	POROSITY	INCLUSIONS	INCOMPLETE PENETRATION	INCOMPLETE FUSION	CRACK	UNDERCUT	SURFACE	OTHER	DISPOSITION JOINT A 1 . 23	ACCEPT	REJECT	REMARKS
-4	30	.063	-	0-1	O	1	1				1	1	*	VERT UP	X		Prior to removal of weld reinforcement.
																	*Spatter

CODE
. ACCEPTABLE
. BORDERLINE
. EXCESSIVE

SINGLE FILM ☒
MULTIFILM ☐
BOTH ☐

RADIATION SOURCE:
X-RAY: KV 70 mA 2
IR-192: CURIES

NO. OF VIEWS	FILM SIZE AND QUANTITY			
	4½×17	4½×10		
1	2			

PREPARED BY T . Moore
APPROVED BY R. D. Bell
ACCEPTED BY

RADIOGRAPHER(S) T. Moore/C.Krofta

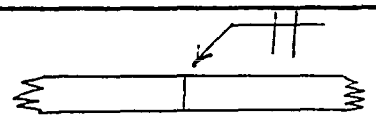
QA-RT-2

TODD PACIFIC SHIPYARDS CORPORATION

SEATTLE DIVISION

WELDING PROCEDURE QUALIFICATION TEST SUMMARY

TEST SERIES NO. A1.14
PROCEDURE NO.
PROCESS GMAW
CONTRACT MARAD SP-7
DATE 12/1/83



QUALIFICATION JOINT

MATERIALS:
BASE SPEC. QQ-A-150/7 5086 H-32
MATL. THICKNESS .063"
FILLER SPEC. AWS A5.10-80 ER 5556
FILLER DIA. 3/64"
SHIELDING GAS 75%HE/25%AR
FLUX AND SIZE NA

EQUIPMENT:
POWER SUPPLY AIRCO PA 350
TORCH OR HOLDER TYPE BINZEL
CUP TYPE & SIZE METALLIC 3/4"
ELECTRODE TYPE & SIZE NA

OPERATING PARAMETERS:
WELDING POS. HORIZONTAL NO. PASSES 1
PREHEAT 60° MIN INTERPASS TEMP. NA
CURRENT CHARAC. DC RP
CURRENT RANGE 50
VOLTAGE RANGE 15
WIRE FEED IPM 168
SHIELD FLOW 40 CFH
TRAVEL SPEED 18 IPM
MAX. HEAT INPUT J/IN NA
HEAT TREAT NA
OTHER

NDT TESTS:
[X] VIS. [X] PT [ ] UT [X] RT [ ] MT

DT TESTS:

	TEST	PLATE OR SPEC. SER. NO.
X	RST	Sat. Report # E28426-1
	HRDNS	
	CHARPY	
	SIDE BEND	
X	ROOT BEND	Sat. Report # E28426-1
X	FACE BEND	Sat. Report # E28426-1
	FILLET BEND	
	FILLET BREAK	
	TRANS. SHEAR	
	LONG SHEAR	
	EXPL. BULGE	
	OTHER	

RESULTS:
Visual - No visible defects
P.T. Acceptable - Report # 1610 attached
R.T. Acceptable - Report # 7038 attached

REMARKS:

J.H. HITCH — JH Hitch — 10879 — J. JOHNSTON

WELD OPR. — CLOCK NO. — TEST BY — QUAL. RANGE

THIS CERTIFIES THAT THE DATA HEREIN IS COMPLETE AND ACCURATE TO BEST POSSIBLE KNOWLEDGE AND THAT TESTING AND EVALUATION WAS CONDUCTED IN ACCORDANCE WITH THE REQUIREMENTS LISTED BELOW.

James C Johnston
WELDING ENGINEER DATE

TODD SHIPYARDS CORPORATION
SEATTLE DIVISION
QUALITY ASSURANCE DEPARTMENT

DATE 5-10-83

TODD ORDER NO. 4787 . ITEM NO. 101.00 REPORT NO. 1610

DYE PENETRANT NONDESTRUCTIVE TEST REPORT

JOB DESCRIPTION	
MARAD PLATE GMAW SHORT ARC PROCESS	
FOR: TWPS NO. A 1 . 14	MATERIAL: Aluminum
PENETRANT EQUIP. DUBL-CHEK; VISIBLE RED	PENETRANT TIME: 15-20 min.
REPORTS TO: Distribution	DEVELOPMENT TIME : 7-30 min.
PER SPEC: MIL-STD-271 E , NAVSHIPS 0900-003-8000, CLASS I	

CONTRACT NO. NNS POM 70200-R

Liquid penetrant inspection of weld was found to be acceptable.

QA-PT-

PENETRANT INSPECTOR R. Bell

Cable "Robin" New York

TODD SHIPYARDS CORPORATION

Seattle Division: 1801 16th Avenue, S.W. Seattle, Washington 98124 • 623-1635 (206)

REPORT NO. 7038
DATE 5/9/83

RADIOGRAPHIC INSPECTION REPORT-WELDMENTS-- CONTRACT NO. NNS POM-70200-R HULL N/A

JOB NAME TWPS No. A 1 . 14 JOB NO. 4787 ITEM NO. 101.00 PAGE 1 of 1

DESCRIPTION MARAD PLATE GMAW : SHORT ARC PROCESS MAT'L Aluminum .063 QUANTITY 1

RSS NO. WQ-001-A QUALITY LEVEL: 2-2T [X] 2-4T [ ] --% RT: 100% [X] 50% [ ] 10% [ ] SPOT [ ]

MIL- STD-271-E [X]
NAVSHIPS 0900-003-9000, CLASS 1
ABS CLASS A [ ] CLASS B [ ]
OTHER:

FILM TYPE(S)	SFD (INCHES)	THICKNESS (INCHES)	SEQUENCE NO.	VIEW	ORIG. or REP.	POROSITY	INCLUSIONS	INCOMPLETE PENETRATION	INCOMPLETE FUSION	CRACK	UNDERCUT	SURFACE	OTHER	DISPOSITION: JOINT A 1 - 14	ACCEPT	REJECT	REMARKS
-4	30	.063	-	0-1	0	1					1	1	*	HORIZ	X		Prior to removal of weld reinforcement
																	*Spatter

CODE
. ACCEPTABLE
. BORDERLINE
. EXCESSIVE

SINGLE FILM [X]
MULTIFILM [ ]
BOTH [ ]

RADIATION SOURCE:
X-RAY: KV 70 mA 2
IR-192: CURIES

NO. OF VIEWS	FILM SIZE AND QUANTITY			
	4½×17	4½×10		
1	2			

PREPARED BY T. Moore

APPROVED BY R. D. Bell

ACCEPTED BY

RADIOGRAPHER(S) T. Moore/C.Krofta

QA-RT-2

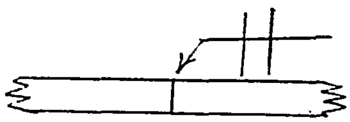
PACIFIC SHIPYARDS CORPORATION

TODD

SEATTLE DIVISION

WELDING PROCEDURE QUALIFICATION TEST SUMMARY

TEST SERIES NO. A2.5
PROCEDURE NO.
PROCESS GMAW
CONTRACT MARAD SP-7
DATE 12/1/83



QUALIFICATION JOINT

MATERIALS:
BASE SPEC. QQ-A-150/7
5086 H-32
MATL. THICKNESS .063"
FILLER SPEC. AWS A5.10 - 80
ER 5556
FILLER DIA. 3/64"
SHIELDING GAS 75%HE/25%AR
FLUX AND SIZE NA

EQUIPMENT:
POWER SUPPLY AIRCO PA 350
TORCH OR HOLDER TYPE BINZEL
CUP TYPE & SIZE METALLIC 3/4"
ELECTRODE TYPE & SIZE NA

OPERATING PARAMETERS:
WELDING POS. OVERHEAD NO. PASSES 1
PREHEAT 60° MIN INTERPASS TEMP. NA
CURRENT CHARAC. D.C. R.P.
CURRENT RANGE 50
VOLTAGE RANGE 15.5
WIRE FEED IPM 155
SHIELD FLOW 40 CFH
TRAVEL SPEED 20 IPM
MAX. HEAT INPUT J/IN NA
HEAT TREAT NA
OTHER

NDT TESTS:
[X] VIS. [X] PT [ ] UT [X] RT [ ] MT

DT TESTS:	PLATE OR SPEC. SER. NO.
[X] RST	Sat. Report # E28426-4
[ ] HRDNS	
[ ] CHARPY	
[ ] SIDE BEND	
[X] ROOT BEND	Sat. Report # E28426-4
[X] FACE BEND	Sat. Report # E28426-4
[ ] FILLET BEND	
[ ] FILLET BREAK	
[ ] TRANS.SHEAR	
[ ] LONG SHEAR	
[ ] EXPL.BULGE	
[ ] OTHER	

RESULTS:
Visual - No visible defects

P.T. Acceptable - Report # 1612 attached

R.T. Acceptable - Report # 7040 attached

REMARKS:

J.H. HITCH J H Hitch 10879 J. JOHNSTON
WELD OPR. CLOCK NO. TEST BY QUAL. RANGE

THIS CERTIFIES THAT THE DATA HEREIN IS COMPLETE AND ACCURATE TO BEST POSSIBLE KNOWLEDGE AND THAT TESTING AND EVALUATION WAS CONDUCTED IN ACCORDANCE WITH THE REQUIREMENTS LISTED BELOW.

James C Johnston
WELDING ENGINEER DATE

TODD SHIPYARDS CORPORATION
SEATTLE DIVISION
QUALITY ASSURANCE DEPARTMENT

DATE 5-10-83

TODD ORDER NO. 4787 . ITEM NO. 101.00 REPORT NO. 1612

DYE PENETRANT NONDESTRUCTIVE TEST REPORT

JOB DESCRIPTION

MARAD PLATE GMAW SHORT ARC PROCESS

FOR: TWPS No. A 2.5	MATERIAL: Aluminum
PENERANT EQUIP. DUBL-CHEK; VISIBLE RED	PENETRANT TIME: 15-20 min.
REPORTS TO: Distribution	DEVELOPMENT TIME : 7-30 min.
PER SPEC: MIL-STD-271 E , NAVSHIPS 0900-003-8000, CLASS I	

CONTRACT NO. NNS POM 70200-R

Liquid penetrant inspection of weld was found to be acceptable.

PENETRANT INSPECTOR B. Dyer
R. Bell

QA-PT-

Cable "Robin" New York

TODD SHIPYARDS CORPORATION

Seattle Division: 1801 16th Avenue, S.W. Seattle, Washington 98124 - 623-1635 (206)

REPORT NO. 7040
DATE 5/9/83

ADIOGRAPHIC INSPECTION REPORT-WELDMENTS-- CONTRACT NO. NNS POM-70200-R HULL N/A

IB NAME TWPS No. A 2.5 JOB NO. 4787 ITEM NO. 101.00 PAGE 1 of 1

ESCRIPTION MARAD PLATE GMAW SHORT ARC PROCESS MAT'L Aluminum .063 QUANTITY 1

SS NO. WQ-001-A QUALITY LEVEL: 2-2T [X] 2-4T [ ] --% RT: 100% [X] 50% [ ] 10% [ ] SPOT [ ].

MIL- STD-271-E [X]
NAVSHIPS 0900-003-9000, CLASS 1
ABS CLASS A [ ] CLASS B [ ]
OTHER:

FILM TYPE(S)	SFD (INCHES)	THICKNESS (INCHES)	SEQUENCE NO.	VIEW	ORIG. or REP.	POROSITY	INCLUSIONS	INCOMPLETE PENETRATION	INCOMPLETE FUSION	CRACK	UNDERCUT	SURFACE	OTHER	DISPOSITION JOINT A 2.5	ACCEPT	REJECT	REMARKS
4	30	.063	-	0-1	0	1	1				1	1	*	OVHD	X		Prior to removal of weld reinforcement
																	*Spatter

CODE
ACCEPTABLE
BORDERLINE
EXCESSIVE

RADIATION SOURCE:
X-RAY: KV 70 mA 2
IR-192: CURIES N/A

SINGLE FILM [X]
MULTIFILM [ ]
BOTH [ ]

NO. OF VIEWS	FILM SIZE AND QUANTITY			
	4½×17	4½×10		
1	2			

PREPARED BY T. Moore

APPROVED BY R. D. Bell

ACCEPTED BY

RADIOGRAPHER(S) T. Moore/ C. Krofta

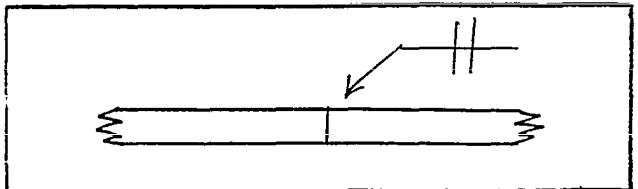
QA-RT-2

TODD PACIFIC SHIPYARDS CORPORATION

SEATTLE DIVISION

WELDING PROCEDURE QUALIFICATION TEST SUMMARY

TEST SERIES NO. B1.18
PROCEDURE NO.
PROCESS GMAW
CONTRACT MARAD SP-7
DATE 12/1/83



QUALIFICATION JOINT

MATERIALS:

BASE SPEC. QQ-A-150-7
5086 H-32
MATL. THICKNESS .100"
FILLER SPEC. AWS A5.10-80
ER 5356
FILLER DIA. .030"
SHIELDING GAS 75%HE/25%AR
FLUX AND SIZE NA

EQUIPMENT:

POWER SUPPLY ATRCO PA 3-A
TORCH OR HOLDER TYPE AH 35C-2
CUP TYPE & SIZE STRAIGHT NOZZLE-3/4"
ELECTRODE TYPE & SIZE NA

OPERATING PARAMETERS:

WELDING POS. VERTICAL-UP NO. PASSES 1
PREHEAT 60°MIN INTERPASS TEMP. NA
CURRENT CHARAC. D.C. R.P.
CURRENT RANGE 45 AMP.
VOLTAGE RANGE 19 VOLTS
WIRE FEED IPM 300 I.P.M.
SHIELD FLOW 40 CFH
TRAVEL SPEED 15.6 I.P.M.
MAX. HEAT INPUT J/IN NA
HEAT TREAT NA
OTHER

NDT TESTS:

[X] VIS. [X] PT [ ] UT [X] RT [ ] MT

DT TESTS:

DT TESTS	PLATE OR SPEC. SER. NO.
[X] RST	Sat. Report # E28426-5
[ ] HRDNS	
[ ] CHARPY	
[ ] SIDE BEND	
[X] ROOT BEND	Sat. Report # E28426-5
[X] FACE BEND	Sat. Report # E28426-5
[ ] FILLET BEND	
[ ] FILLET BREAK	
[ ] TRANS.SHEAR	
[ ] LONG SHEAR	
[ ] EXPL.BULGE	
[ ] OTHER	

RESULTS:

Visual - No visible defects

P.T. Acceptable - Report # 1613 attached

R.T. Acceptable - Report # 7041 attached

REMARKS:

J.H. HITCH (signature) 10879 J. JOHNSTON
WELD OPR. CLOCK NO. TEST BY QUAL. RANGE

THIS CERTIFIES THAT THE DATA HEREIN IS COMPLETE AND ACCURATE TO BEST POSSIBLE KNOWLEDGE AND THAT TESTING AND EVALUATION WAS CONDUCTED IN ACCORDANCE WITH THE REQUIREMENTS LISTED BELOW.

James C Johnston
WELDING ENGINEER DATE

WE003

TODD SHIPYARDS CORPORATION
SEATTLE DIVISION
QUALITY ASSURANCE DEPARTMENT

DATE 5-10-83

TODD ORDER NO. 4787 . ITEM No. 101.00 REPORT NO. 1613

DYE PENETRANT NONDESTRUCTIVE TEST REPORT

JOB DESCRIPTION

MARAD PLATE GMAW SHORT ARC PROCESS

FOR: TWPS No. B 1 . 18	MATERIAL: Aluminum
PENETRANT EQUIP. DUBL-CHEK; VISIBLE RED	PENETRANT TIME: 15-20 min.
REPORTS TO: Distribution	DEVELOPMENT TIME : 7-30 min.
PER SPEC: MI L-STD-271 E , NAVSHIPS 0900-003-8000, CLASS I	

CONTRACT NO. NNS POM 70200-R

Liquid penetrant inspection of weld was found to be acceptable.

B. Dyer
PENETRANT INSPECTOR R. Bell

QA-PT-

Cable "Robin" New York

TODD SHIPYARDS CORPORATION

Seattle Division: 1801 16th Avenue, S.W. Seattle, Washington 98124 • 623-1635 (206)

REPORT NO. 7041
DATE 5/9/83

RADIOGRAPHIC INSPECTION REPORT-WELDMENTS-- CONTRACT NO. NNS POM-70200-R HULL N/A

JOB NAME TWPS No. B 1 . 18 JOB NO. 4787 ITEM NO. 101.00 PAGE 1 of 1

DESCRIPTION MARAD PLATE GMAW SHORT ARC PROCESS MAT'L Aluminum .100 QUANTITY 1

RSS NO. WQ-001-A QUALITY LEVEL: 2-2T ☒ 2-4T ☐ --% RT: 100% ☒ 50% ☐ 10% ☐ SPOT ☐

MIL- STD-271-E ☒
NAVSHIPS 0900-003-9000, CLASS 1
ABS CLASS A ☐ CLASS B ☐
OTHER:

FILM TYPE(S)	SFD (INCHES)	THICKNESS (INCHES)	SEQUENCE NO.	VIEW	ORIG. or REP.	POROSITY	INCLUSIONS	INCOMPLETE PENETRATION	INCOMPLETE FUSION	CRACK	UNDERCUT	SURFACE	OTHER	DISPOSITION: JOINT B 1 . 18	ACCEPT	REJECT	REMARKS
-4	30	.100	-	0-1	0	1	1				1	1	*	VERT UP	X		Prior to removal of weld reinforcement
																	*Spatter

CODE
ACCEPTABLE
BORDERLINE
EXCESSIVE

SINGLE FILM ☒
MULTIFILM ☐
BOTH ☐

RADIATION SOURCE:
X-RAY: KV 100 mA 2
IR-192: CURIES N/A

NO. OF VIEWS	FILM SIZE AND QUANTITY			
	4½×17	4½×10		
1	2			

PREPARED BY T. Moore
APPROVED BY R. D. Bell
ACCEPTED BY

RADIOGRAPHER(S) Moore/Krofta

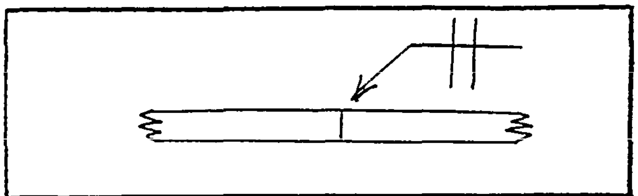
QA-RT-2

TODD PACIFIC SHIPYARDS CORPORATION

SEATTLE DIVISION

WELDING PROCEDURE QUALIFICATION TEST SUMMARY

TEST SERIES NO. B.50
PROCEDURE NO.
PROCESS GMAW
CONTRACT MARAD SP-7
DATE 12/1/83



QUALIFICATION JOINT

MATERIALS:
BASE SPEC. QQ-A-150/7
5086 H-32
MATL. THICKNESS .100
FILLER SPEC. AWS A5.10-80
ER 5356
FILLER DIA. .035"
SHIELDING GAS 75%HE/25%AR
FLUX AND SIZE NA

EQUIPMENT:
POWER SUPPLY AIRCO PA 3A
TORCH OR HOLDER TYPE AH 35 C-2
CUP TYPE & SIZE METALLIC 3/4"
ELECTRODE TYPE & SIZE NA

OPERATING PARAMETERS:
WELDING POS. HORIZONTAL NO. PASSES 1
PREHEAT 60° MIN INTERPASS TEMP. NA
CURRENT CHARAC. D.C. R.P.
CURRENT RANGE 55
VOLTAGE RANGE 19
WIRE FEED IPM 260
SHIELD FLOW 40 CFH
TRAVEL SPEED 18 IPM
MAX. HEAT INPUT J/IN NA
HEAT TREAT NA
OTHER

NDT TESTS:
[X] VIS. [X] PT [ ] UT [X] RT [ ] MT

DT TESTS:

	DT TESTS	PLATE OR SPEC. SER. NO.
X	RST	Sat. Report # E28426-6
	HRDNS	
	CHARPY	
	SIDE BEND	
X	ROOT BEND	Sat. Report # E28426-6
X	FACE BEND	Sat. Report # E28426-6
	FILLET BEND	
	FILLET BREAK	
	TRANS. SHEAR	
	LONG SHEAR	
	EXPL. BULGE	
	OTHER	

RESULTS:
Visual - No visible defects
P.T. Acceptable - Report # 1607 attached
R.T. Acceptable - Report # 7050 attached

REMARKS:

J.H. HITCH JH Hitch 10879 J.JOHNSTON
WELD OPR. CLOCK NO. TEST BY QUAL. RANGE

THIS CERTIFIES THAT THE DATA HEREIN IS COMPLETE AND ACCURATE TO BEST POSSIBLE KNOWLEDGE AND THAT TESTING AND EVALUATION WAS CONDUCTED IN ACCORDANCE WITH THE REQUIREMENTS LISTED BELOW.

James C Johnston
WELDING ENGINEER DATE

TODD SHIPYARDS CORPORATION
SEATTLE DIVISION
QUALITY ASSURANCE DEPARTMENT

DATE 5-10-83

TODD ORDER NO. 4787 . ITEM NO. 101.00 REPORT NO. 1607

DYE PENETRANT NONDESTRUCTIVE TEST REPORT

JOB DESCRIPTION MARD PLATE GMAW SHORT ARC PROCESS	
FOR: TWPS No. B . 50	MATERIAL: Aluminum
PENETRANT EQUIP. DUBL-CHEK; VISIBLE RED	PENETRANT TIME: 15-20min.
REPORTS TO: Distribution	DEVELOPMENT TIME : 7-30 min.
PER SPEC: MIL-STD-271 E , NAVSHIPS 0900-003-8000, CLASS I	

CONTRACT NO. NNS POM 70200-R

Liquid penetrant inspection of weld was found to be acceptable.

QA-PT.

PENETRANT INSPECTOR B. Dyer
R. Bell

TODD
SEATTLE

Cable "Robin" New York

TODD SHIPYARDS CORPORATION

Seattle Division: 1801 16th Avenue, S.W. Seattle, Washington 98124 • 623-1635 (206)

REPORT NO. 7050
DATE 5/10/83

RADIOGRAPHIC INSPECTION REPORT-WELDMENTS CONTRACT NO. NNS POM 70200-R HULL N/A

JOB NAME TWPS No. B . 50 JOB NO. 4787 ITEM NO. 101.00 PAGE 1 of 1

DESCRIPTION MARAD PLATE GMAW SHORT ARC PROCESS MAT'L Aluminum .100 QUANTITY 1

PROCESS NO. WQ-001-A QUALITY LEVEL: 2-2T [X] 2-4T [ ] --% RT: 100% [X] 50% [ ] 10% [ ] SPOT [ ]

MIL- STD-271-E [X]
NAVSHIPS 0900-003-9000, CLASS 1
ABS CLASS A [ ] CLASS B [ ]
OTHER:

FILM TYPE(S)	SFD (INCHES)	THICKNESS (INCHES)	SEQUENCE NO.	VIEW	ORIG. or REP.	POROSITY	INCLUSIONS	INCOMPLETE PENETRATION	INCOMPLETE FUSION	CRACK	UNDERCUT	SURFACE	OTHER	DISPOSITION: JOINT B . 50	ACCEPT	REJECT	REMARKS
-4	30	.100	-	0-1	0	1	1				1	1		HORIZ	X		Prior to removal of weld reinforcement

CODE
ACCEPTABLE
BORDERLINE
EXCESSIVE

RADIATION SOURCE:
X-RAY: KV 70 mA 2
IR-192: CURIES N/A

SINGLE FILM [X]
MULTIFILM [ ]
BOTH [ ]

NO. OF VIEWS	FILM SIZE AND QUANTITY			
	4½×17	4½×10		
1	2			

PREPARED BY T. Moore
APPROVED BY R. Bell
ACCEPTED BY

RADIOGRAPHER(S) T. Moore/C. Krofta

QA-RT-2

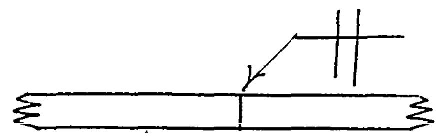
PACIFIC SHIPYARDS CORPORATION

TODD

SEATTLE DIVISION

WELDING PROCEDURE QUALIFICATION TEST SUMMARY

TEST SERIES NO. B.74
PROCEDURE NO.
PROCESS GMAW
CONTRACT MARAD SP-7
DATE 12/1/83



QUALIFICATION JOINT

MATERIALS:
BASE SPEC. QQ-A-150/7
5086 H-32
MATL. THICKNESS .100"
FILLER SPEC. AWS A5.10-80
ER 5356
FILLER DIA. 3/64"
SHIELDING GAS 75%HE/25%AR
FLUX AND SIZE NA
EQUIPMENT:
POWER SUPPLY AIRCO PA 350
TORCH OR HOLDER TYPE BINZEL
CUP TYPE & SIZE METALLIC 3/4"
ELECTRODE TYPE & SIZE NA

OPERATING PARAMETERS:
WELDING POS. OVERHEAD NO. PASSES 1
PREHEAT 60°MIN INTERPASS TEMP. NA
CURRENT CHARAC. D.C. R.P.
CURRENT RANGE 70
VOLTAGE RANGE 16
WIRE FEED IPM 205
SHIELD FLOW 40 CFH
TRAVEL SPEED 17 IPM
MAX. HEAT INPUT J/IN NA
HEAT TREAT NA
OTHER

NDT TESTS:

[X] VIS. [ ] PT [X] UT [X] RT [ ] MT

RESULTS:
Viaual - No visible defects

P.T. Acceptable - Report # 1614 attached

R.T. Acceptable - Report # 7043 attached

DT TESTS:

	DT TESTS	PLATE OR SPEC. SER. NO.
X	RST	Sat. Report # E28426-7
	HRDNS	
	CHARPY	
	SIDE BEND	
X	ROOT BEND	Sat. Report # E28426-7
X	FACE BEND	Sat. Report # E28426-7
	FILLET BEND	
	FILLET BREAK	
	TRANS.SHEAR	
	LONG SHEAR	
	EXPL.BULGE	
	OTHER	

REMARKS:

J.H. HITCH J H Hitch 10879 J.JOHNSTON
WELD OPR. CLOCK NO. TEST BY QUAL. RANGE

THIS CERTIFIES THAT THE DATA HEREIN IS COMPLETE AND ACCURATE TO BEST POSSIBLE KNOWLEDGE AND THAT TESTING AND EVALUATION WAS CONDUCTED IN ACCORDANCE WITH THE REQUIREMENTS LISTED BELOW.

James C Johnston
WELDING ENGINEER DATE

WE003

TODD SHIPYARDS CORPORATION
SEATTLE DIVISION
QUALITY ASSURANCE DEPARTMENT

DATE 5-10-83

TODD ORDER NO. 4787 . ITEM NO. 101.00 REPORT NO. 1614

DYE PENETRANT NONDESTRUCTIVE TEST REPORT

JOB DESCRIPTION

MARAD PLATE GMAW SHORT ARC PROCESS

FOR: TWPS No. B . 74	MATERIAL: ,Aluminum
PENETRANT EQUIP. DUBL-CHIIK; VISIBLE RED	PENETRANT TIME: 15-20 min
REPORTS TO: Distribution	DEVELOPMENT TIME: 7-30 min.
PER SPEC: MIL-STD-271 E , NAVSHIPS 0900-003-8000, CIASS I	

CONTRACT NO. NNS POM 70200-R

Liquid penetrant inspection of weld was found to be acceptable.

PENETRANT INSPECTOR B. Dyer R. Bell

QA-PT-

Cable "Robin" New York

TODD SHIPYARDS CORPORATION

Seattle Division: 1801 16th Avenue, S.W. Seattle, Washington 98124 • 623-1635 (206)

REPORT NO. 7043
DATE 5/6/83

RADIOGRAPHIC INSPECTION REPORT-WELDMENTS-- CONTRACT NO. NNS POM-70200-R HULL N/A

JOB NAME TWPS No. B . 74 JOB NO. 4787 ITEM NO. 101.00 PAGE 1 of 1

DESCRIPTION MARAD PLATE GMAW SHORT ARC PROCESS MAT'L Aluminum .100 QUANTITY 1

PROCESS NO. WQ-001-A QUALITY LEVEL: 2-2T [X] 2-4T [ ] --% RT: 100% [X] 50% [ ] 10% [ ] SPOT [ ]

MIL- STD-271-E [X]
NAVSHIPS 0900-003-9000, CLASS 1
ABS CLASS A [ ] CLASS B [ ]
OTHER:

FILM TYPE(S)	SFD(INCHES)	THICKNESS (INCHES)	SEQUENCE NO.	VIEW	ORIG. or REP.	POROSITY	INCLUSIONS	INCOMPLETE PENETRATION	INCOMPLETE FUSION	CRACK	UNDERCUT	SURFACE	OTHER	DISPOSITION JOINT B .74	ACCEPT	REJECT	REMARKS
-4	30	.100	-	0-1	0						1	1		OVHD	X		Prior to removal of weld reinforcement

CODE
ACCEPTABLE
BORDERLINE
EXCESSIVE

SINGLE FILM [X]
MULTIFILM [ ]
BOTH [ ]

RADIATION SOURCE:
X-RAY: KV 70 mA 2
IR-192: CURIES N/A

NO.OF VIEWS	FILM SIZE AND QUANTITY			
	4½×17	4½×10		
1	2			

PREPARED BY T. Moore

APPROVED BY R. Bell

ACCEPTED BY

RADIOGRAPHER(S) T. Moore

QA-RT-2

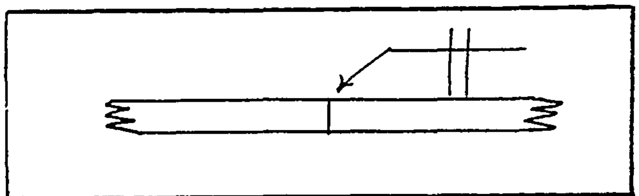
PACIFIC SHIPYARDS CORPORATION

TODD

SEATTLE DIVISION

WELDING PROCEDURE QUALIFICATION TEST SUMMARY

TEST SERIES NO. C.60
PROCEDURE NO.
PROCESS GMAW
CONTRACT MARAD SP-7
DATE 12/1/83



QUALIFICATION JOINT

OPERATING PARAMETERS:
WELDING POS. VERTICAL-UP NO. PASSES 1
PREHEAT 60°MIN INTERPASS TEMP. NA
CURRENT CHARAC. D.C. R.P.
CURRENT RANGE 70
VOLTAGE RANGE 17
WIRE FEED IPM 225
SHIELD FLOW 40 CFH
TRAVEL SPEED 12.8 IPM
MAX. HEAT INPUT J/IN NA
HEAT TREAT NA
OTHER

MATERIALS:
BASE SPEC. QQ-A-250/6
5083 H323
MATL. THICKNESS .125"
FILLER SPEC. AWS A5.10-80
ER 5556
FILLER DIA. 3/64"
SHIELDING GAS 75%HE/25%AR
FLUX AND SIZE NA
EQUIPMENT:
POWER SUPPLY AIRCO PA 350
TORCH OR HOLDER TYPE BINZEL
CUP TYPE & SIZE METALLIC 3/4"
ELECTRODE TYPE & SIZE NA

NDT TESTS:

[x] VIS. [x] PT [ ] UT [x] RT [ ] MT

RESULTS:
Visual - No visible defects
P.T. Acceptable - Report # 1617 attached
R.T. Acceptable - Report # 7045 attached

DT TESTS:	PLATE OR SPEC. SER. NO.
[X] RST	Sat. Report # E28426-10
[ ] HRDNS	
[ ] CHARPY	
[ ] SIDE BEND	
[X] ROOT BEND	Sat. Report # E28426-10
[X] FACE BEND	Sat. Report # E28426-10
[ ] FILLET BEND	
[ ] FILLET BREAK	
[ ] TRANS. SHEAR	
[ ] LONG SHEAR	
[ ] EXPL. BULGE	
[ ] OTHER	

REMARKS:

J.H. HITCH *J H Hitch*	10879	J. JOHNSTON	
WELD OPR.	CLOCK NO.	TEST BY	QUAL. RANGE

THIS CERTIFIES THAT THE DATA HEREIN IS COMPLETE AND ACCURATE TO BEST POSSIBLE KNOWLEDGE AND THAT TESTING AND EVALUATION WAS CONDUCTED IN ACCORDANCE WITH THE REQUIREMENTS LISTED BELOW.

James C Johnston
WELDING ENGINEER DATE

WF003

TODD SHIPYARDS CORPORATION
SEATTLE DIVISION
QUALITY ASSURANCE DEPARTMENT

DATE 5-10-83

TODD ORDER NO. 4787 . ITEM NO. 101.00 REPORT NO. 1617

DYE PENETRANT NONDESTRUCTIVE TEST REPORT

JOB DESCRIPTION MARAD PLATE GMAW SHORT ARC PROCESS	
FOR: TWPS No. C . 60	MATERIAL: Aluminum
PENETRANT EQUIP. DUBL-CHEK; VISIBLE RED	PENETRANT TIME: 15-20 min.
REPORTS TO: Distribution	DEVELOPMENT TIME : 7-30 min.
PER SPEC: MIL-STD-271 E , NAVSHIPS 0900-003-8000, CLASS I	

CONTRACT NO. NNS POM 70200-R

Liquid penetrant inspection of weld was found to be acceptable.

QA-PT.

PENETRANT INSPECTOR B. Dyer
R. Bell

Cable "Robin" New York

TODD SHIPYARDS CORPORATION

Seattle Division: 1801 16th Avenue, S.W. Seattle, Washington 98124 • 623-1635 (206)

REPORT NO. 7045
DATE 5/6/83

RADIOGRAPHIC INSPECTION REPORT-WELDMENTS-- CONTRACT NO. NNS POM 70200-R HULL N/A

JOB NAME TWPS No. C . 60 JOB NO. 4787 ITEM NO. 101.00 PAGE 1 of 1

DESCRIPTION MARAD PLATE GMAW SHORT ARC PROCESS MAT'L Aluminum .125 QUANTITY 1

PROCESS NO. WQ-001-A QUALITY LEVEL: 2-2T ☒ 2-4T ☐ --% RT: 100% ☒ 50% ☐ 10% ☐ SPOT ☐

MIL- STD-271-E ☒
NAVSHIPS 0900-003-9000, CLASS 1
ABS CLASS A ☐ CLASS B ☐
OTHER:

FILM TYPE(S)	SFD(INCHES)	THICKNESS (INCHES)	SEQUENCE NO.	VIEW	ORIG. or REP.	POROSITY	INCLUSIONS	INCOMPLETE PENETRATION	INCOMPLETE FUSION	CRACK	UNDERCUT	SURFACE	OTHER	DISPOSITION: JOINT C .60	ACCEPT	REJECT	REMARKS
-4	30	.125	-	0-1	0	1	1				1	1	*	VERT UP	X		Prior to removal of weld reinforcement
																	*Spatter

CODE
ACCEPTABLE
BORDERLINE
EXCESSIVE

SINGLE FILM ☒
MULTIFILM ☐
BOTH ☐

RADIATION SOURCE:
X-RAY: KV 70 mA 2
IR-192: CURIES N/A

NO. OF VIEWS	FILM SIZE AND QUANTITY			
	4½×17	4½×10		
1	2			

PREPARED BY T. Moore

APPROVED BY R. Bell

ACCEPTED BY

RADIOGRAPHER(S) T. Moore

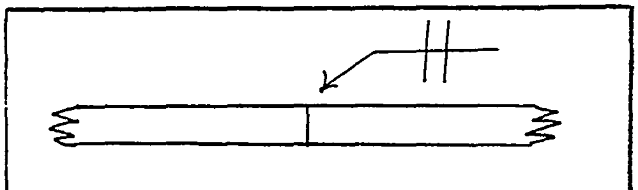
QA-RT-2

PACIFIC SHIPYARDS CORPORATION
TODD

SEATTLE DIVISION

WELDING PROCEDURE QUALIFICATION TEST SUMMARY

TEST SERIES NO. C.63
PROCEDURE NO.
PROCESS GMAW
CONTRACT MARAD SP-7
DATE 12/1/83



QUALIFICATION JOINT

MATERIALS:
BASE SPEC. QQ-A-250/6
5083 H-323
MATL. THICKNESS .125"
FILLER SPEC. AWS A5.10-80
ER 5356
FILLER DIA. 3/64"
SHIELDING GAS 75%HE/25%AR
FLUX AND SIZE NA
EQUIPMENT:
POWER SUPPLY AIRCO PA 350
TORCH OR HOLDER TYPE BINZEL
CUP TYPE & SIZE METALLIC 1/4"
ELECTRODE TYPE & SIZE NA

OPERATING PARAMETERS:
WELDING POS. VERTICAL-UP NO. PASSES 1
PREHEAT 60°MIN INTERPASS TEMP. NA
CURRENT CHARAC. D.C. R.P.
CURRENT RANGE 70

VOLTAGE RANGE 17

WIRE FEED IPM 240

SHIELD FLOW 40 CFH
TRAVEL SPEED 14.1 IPM

MAX. HEAT INPUT J/IN NA
HEAT TREAT NA

OTHER

NDT TESTS:

[X] VIS. [X] PT [ ] UT [X] RT [ ] MT

DT TESTS:	PLATE OR SPEC. SER. NO.
[X] RST	Sat. Report # E28426-11
[ ] HRDNS	
[ ] CHARPY	
[ ] SIDE BEND	
[X] ROOT BEND	Sat. Report # E28426-11
[X] FACE BEND	Sat. Report # E28426-11
[ ] FILLET BEND	
[ ] FILLET BREAK	
[ ] TRANS. SHEAR	
[ ] LONG SHEAR	
[ ] EXPL. BULGE	
[ ] OTHER	

RESULTS:
Visual - No visible defects

P.T. Acceptable - Report # 1618 attached

R.T. Acceptable - Report # 7044 attached

REMARKS:

J.H. HITCH — J H Hitch — 10879 — J.JOHNSTON
WELD OPR. — CLOCK NO. — TEST BY — QUAL. RANGE

THIS CERTIFIES THAT THE DATA HEREIN IS COMPLETE AND ACCURATE TO BEST POSSIBLE KNOWLEDGE AND THAT TESTING AND EVALUATION WAS CONDUCTED IN ACCORDANCE WITH THE REQUIREMENTS LISTED BELOW.

James C Johnston
WELDING ENGINEER — DATE

TODD SHIPYARDS CORPORATION .
SEATTLE DIVISION
QUALITY ASSURANCE DEPARTMENT

DATE 5-10-83

TODD ORDER NO. 4787 . ITEM NO. 101.00 REPORT NO. 1618

DYE PENETRANT NONDESTRUCTIVE TEST REPORT

JOB DESCRIPTION

MARAD PLATE GMAW SHORT ARC PROCESS

FOR: TWPS No. C . 63	MATERIAL: Alminum
PENETRANT EQUIP. DUBL-CHEK; VISIBLE RED	PENETRANT TIME: 15-20 min.
REPORTS TO: Distribution	DEVELOPMENT TIME: 7-30 min.

PER SPEC: MIL-STD-271 E , NAVSHIPS 0900-003-8000, CLASS I

CONTRACT NO. NNS POM 70200-R

Liquid penetrant inspection of weld was found to be acceptable.

QA-PT-

PENETRANT INSPECTOR B. Dyer
R. Bell

Cable "Robin" New York

TODD SHIPYARDS CORPORATION

Seattle Division: 1801 16th Avenue, S.W. Seattle, Washington 98124 • 623-1635 (206)

REPORT NO. 7044
DATE 5/9/83

RADIOGRAPHIC INSPECTION REPORT-WELDMENTS--

CONTRACT NO. NNS POM-70200-R HULL N/A

JOB NAME TWPS No. C . 63 JOB NO. 4787 ITEM NO. 101.00 PAGE 1 of 1

DESCRIPTION MARAD PLATE GMAW SHORT ARC PROCESS MAT'L Aluminum .125 QUANTITY 1

PROCESS NO. WQ-001-A QUALITY LEVEL: 2-2T ☒ 2-4T ☐ --% RT: 100% ☒ 50% ☐ 10% ☐ SPOT ☐

MIL- STD-271-E ☒
NAVSHIPS 0900-003-9000, CLASS 1
ABS CLASS A ☐ CLASS B ☐
OTHER:

FILM TYPE(S)	SFD (INCHES)	THICKNESS (INCHES)	SEQUENCE NO.	VIEW	ORIG. or REP.	POROSITY	INCLUSIONS	INCOMPLETE PENETRATION	INCOMPLETE FUSION	CRACK	UNDERCUT	SURFACE	OTHER	DISPOSITION JOINT C . 63	ACCEPT	REJECT	REMARKS
-4	30	.125	-	0-1	0	1					1	1		VERT UP	X		Prior to removal of weld reinforcement

CODE
ACCEPTABLE
BORDERLINE
EXCESSIVE

SINGLE FILM ☒
MULTIFILM ☐
BOTH ☐

RADIATION SOURCE:
X-RAY: KV 70 mA 2
IR-192: CURIES N/A

NO. OF VIEWS	FILM SIZE AND QUANTITY			
	4½×17	4½×10		
1	2			

PREPARED BY T. Moore

APPROVED BY R. W. Bell

ACCEPTED BY

RADIOGRAPHER(S) Moore/Krofta

QA-RT-2

PACIFIC SHIPYARDS CORPORATION

TODD

SEATTLE DIVISION

WELDING PROCEDURE QUALIFICATION TEST SUMMARY

TEST SERIES NO. C.30
PROCEDURE NO.
PROCESS GMAW
CONTRACT MARAD SP-7
DATE 12/1/83

QUALIFICATION JOINT

MATERIALS:
BASE SPEC. QQ-A-250/6 5083 H-323
MATL. THICKNESS .125"
FILLER SPEC. AWS A5.10-80 ER 5556
FILLER DIA. 3/64"
SHIELDING GAS 75%HE/25%AR
FLUX AND SIZE NA

EQUIPMENT:
POWER SUPPLY AIRCO PA 350
TORCH OR HOLDER TYPE BINZEL
CUP TYPE & SIZE METALLIC 3/4"
ELECTRODE TYPE & SIZE NA

OPERATING PARAMETERS:
WELDING POS. HORIZONTAL NO. PASSES 1
PREHEAT 60° MIN INTERPASS TEMP. NA
CURRENT CHARAC. D.C. R.P.
CURRENT RANGE 85
VOLTAGE RANGE 19.5
WIRE FEED IPM 245
SHIELD FLOW 40 CFH
TRAVEL SPEED 15 IPM
MAX. HEAT INPUT J/IN NA
HEAT TREAT NA
OTHER

NDT TESTS:

[x] VIS. [x] PT [ ] UT [x] RT [ ] MT

DT TESTS:		PLATE OR SPEC. SER. NO.
x	RST	Sat. Report # E28426-8
	HRDNS	
	CHARPY	
	SIDE BEND	
x	ROOT BEND	Sat. Report # E28426-8
x	FACE BEND	Sat. Report # E28426-8
	FILLET BEND	
	FILLET BREAK	
	TRANS. SHEAR	
	LONG SHEAR	
	EXPL. BULGE	
	OTHER	

RESULTS:
Visual - No visible defects
P.T. Acceptable - Report # 1615 attached
R.T. Acceptable - Report # 7046 attached

REMARKS:

J.H. HITCH — J H Hitch — 10879 — J.C. JOHNSTON
WELD OPR. — CLOCK NO. — TEST BY — QUAL. RANGE

THIS CERTIFIES THAT THE DATA HEREIN IS COMPLETE AND ACCURATE TO BEST POSSIBLE KNOWLEDGE AND THAT TESTING AND EVALUATION WAS CONDUCTED IN ACCORDANCE WITH THE REQUIREMENTS LISTED BELOW.

James C Johnston

TODD SHIPYARDS CORPORATION
SEATTLE DIVISION
QUALITY ASSURANCE DEPARTMENT

DATE 5-10-83

TODD ORDER NO. 4787 . ITEM NO. 101.00 REPORT NO. 1615

DYE PENETRANT NONDESTRUCTIVE TEST REPORT

JOB DESCRIPTION

MARAD PLATE GMAW SHORT ARC PROCESS

FOR: TWPS No. C . 30	MATERIAL: Aluminum
PENETRANT EQUIP. DUBL-CHEK; VISIBLE RED	PENETRANT TIME: 15.20 min
REPORTS TO: Distribution	DEVELOPMENT TIME: 7-30 min.
PER SPEC: MIL-STD-271 E , NAVSHIPS 0900-003-8000, CLASS I	

CONTRACT NO. NNS POM 70200-R

Liquid penetrant inspection of weld was found to be acceptable.

QA-PT-

PENETRANT INSPECTOR B. Dyer
R. Bell

Cable "Robin" New York

TODD SHIPYARDS CORPORATION

Seattle Division: 1801 16th Avenue, S.W. Seattle, Washington 98124 • 623-1635 (206)

REPORT NO. 7046
DATE 5/6/83

ADIOGRAPHIC INSPECTION REPORT-WELDMENTS-- CONTRACT NO. NNS POM-70200-R HULL N/A

OB NAME TWPS No. C . 30 JOB NO. 4787 ITEM NO. 101.00 PAGE 1 of 1

ESCRIPTION MARAD PLATE GMAW SHORT ARC PROCESS MAT'L Aluminum .125 QUANTITY 1

ISS NO. WQ-001-A QUALITY LEVEL: 2-2T ☒ 2-4T ☐ --% RT: 100% ☒ 50% ☐ 10% ☐ SPOT ☐

MIL- STD-271-E ☒
NAVSHIPS 0900-003-9000, CLASS 1
ABS CLASS A ☐ CLASS B ☐
OTHER:

FILM TYPE(S)	SFD (INCHES)	THICKNESS (INCHES)	SEQUENCE NO.	VIEW	ORIG. or REP.	POROSITY	INCLUSIONS	INCOMPLETE PENETRATION	INCOMPLETE FUSION	CRACK	UNDERCUT	SURFACE	OTHER	DISPOSITION JOINT C . 30	ACCEPT	REJECT	REMARKS
-4	30	.125	-	0-1	0	1					1	1		HORIZ	X		Prior to removal of weld reinforcement

CODE
ACCEPTABLE
BORDERLINE
EXCESSIVE

SINGLE FILM ☒
MULTIFILM ☐
BOTH ☐

RADIATION SOURCE:
X-RAY: KV 70 mA 2
IR-192: CURIES N/A

NO. OF VIEWS	FILM SIZE AND QUANTITY 4½×17	4½×10		
1	2			

PREPARED BY T. Moore

APPROVED BY R. Bell

ACCEPTED BY

RADIOGRAPHER(S) T. Moore

QA-RT-2

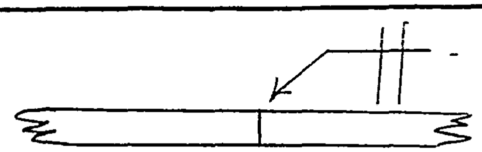
PACIFIC SHIPYARDS CORPORATION

TODD

SEATTLE DIVISION

WELDING PROCEDURE QUALIFICATION TEST SUMMARY

TEST SERIES NO. C.46
PROCEDURE NO.
PROCESS GMAW
CONTRACT MARAD SP-7
DATE 12/1/83



QUALIFICATION JOINT

MATERIALS:
BASE SPEC. QQ-A-250/6
5083 H-323
MATL. THICKNESS .125"
FILLER SPEC. AWS A5.10-80
ER 5356
FILLER DIA. 3/64"
SHIELDING GAS 75%HE/25%AR
FLUX AND SIZE NA

EQUIPMENT:
POWER SUPPLY AIRCO
TORCH OR HOLDER TYPE BINZEL
CUP TYPE & SIZE METALLIC 3/4"
ELECTRODE TYPE & SIZE NA

OPERATING PARAMETERS:
WELDING POS. OVERHEAD NO. PASSES 1
PREHEAT 60°MIN INTERPASS TEMP. NA
CURRENT CHARAC. D.C. R.P.
CURRENT RANGE 105
VOLTAGE RANGE 15
WIRE FEED IPM 280
SHIELD FLOW 40 CFH
TRAVEL SPEED 20 IPM
MAX. HEAT INPUT J/IN NA
HEAT TREAT NA
OTHER

NDT TESTS:

[X] VIS. [X] PT [ ] UT [X] RT [ ] MT

DT TESTS:	PLATE OR SPEC. SER. NO.
[X] RST	Sat. Report # E28426-9
[ ] HRDNS	
[ ] CHARPY	
[ ] SIDE BEND	
[X] ROOT BEND	Sat. Report # E28426-9
[X] FACE BEND	Sat. Report # E28426-9
[ ] FILLET BEND	
[ ] FILLET BREAK	
[ ] TRANS. SHEAR	
[ ] LONG SHEAR	
[ ] EXPL. BULGE	
[ ] OTHER	

RESULTS:
Visual - No visible defects
P.T. Acceptable - Report # 1616 attached
R.T. Acceptable - Report # 7047 attached

REMARKS:

J.H. HITCH *J H Hitch*	10879	J. JOHNSTON	
WELD OPR.	CLOCK NO.	TEST BY	QUAL. RANGE

THIS CERTIFIES THAT THE DATA HEREIN IS COMPLETE AND ACCURATE TO BEST POSSIBLE KNOWLEDGE AND THAT TESTING AND EVALUATION WAS CONDUCTED IN ACCORDANCE WITH THE REQUIREMENTS LISTED BELOW.

James C Johnston
WELDING ENGINEER DATE

TODD SHIPYARDS CORPORATION
SEATTLE DIVISION
QUALITY ASSURANCE DEPARTMENT

DATE 5-10-83

TODD ORDER NO. 4787 . ITEM NO. 101.00 REPORT NO. 1616

DYE PENETRANT NONDESTRUCTIVE TEST REPORT

JOB DESCRIPTION

MARAD PLATE GMAW SHORT ARC PROCESS

FOR: TWPS. C. 46	MATERIAL: Aluminum
PENETRANT EQUIP. DUBL-CHEK; VISIBLE RED	PENETRANT TIME: 15-20min.
REPORTS TO: Distribution	DEVELOPMENT TIME : 7-30 min.
PER SPEC: MIL-STD-271 E , NAVSHIPS 0900-003-8000, CLASS I	

CONTRACT NO. NNS POM 70200-R

Liquid penetrant inspection of weld was found to be acceptable.

QA-PT-

PENETRANT INSPECTOR B. Dyer R. Bell

Cable "Robin" New York

TODD SHIPYARDS CORPORATION

Seattle Division: 1801 16th Avenue, S.W. Seattle, Washington 98124 • 623-1635 (206)

REPORT NO. 7047
DATE 5/6/83

RADIOGRAPHIC INSPECTION REPORT-WELDMENTS-- CONTRACT NO. NNS POM-70200-R HULL N/A

JOB NAME TWPS No. C.46 JOB NO. 4787 ITEM NO. 101.00 PAGE 1 of 1

DESCRIPTION MARAD PLATE GMAW SHORT ARC PROCESS MAT'L Aluminum .125 QUANTITY 1

RSS NO. WQ -001-A QUALITY LEVEL: 2-2T ☒ 2-4T ☐ --% RT: 100% ☒ 50% ☐ 10% ☐ SPOT ☐

MIL- STD-271-E ☒
NAVSHIPS 0900-003-9000, CLASS 1
ABS CLASS A ☐ CLASS B ☐
OTHER:

FILM TYPE(S)	SFD (INCHES)	THICKNESS (INCHES)	SEQUENCE NO.	VIEW	ORIG. or REP.	POROSITY	INCLUSIONS	INCOMPLETE PENETRATION	INCOMPLETE FUSION	CRACK	UNDERCUT	SURFACE	OTHER	DISPOSITION: JOINT C . 46	ACCEPT	REJECT	REMARKS
-4	30	.125	-	0-1	0	1	1				1	1		OVHD	X		Prior to removal of weld reinforcement

CODE
ACCEPTABLE
BORDERLINE
EXCESSIVE

RADIATION SOURCE:
X-RAY: KV 70 mA 2
IR-192: CURIES N/A

PREPARED BY T. Moore

APPROVED BY R. Bell

ACCEPTED BY

SINGLE FILM ☒
MULTIFILM ☐
BOTH ☐

NO. OF VIEWS	FILM SIZE AND QUANTITY			
	4½×17	4½×10		
1	2			

RADIOGRAPHER(S) T. Moore

QA-RT-2

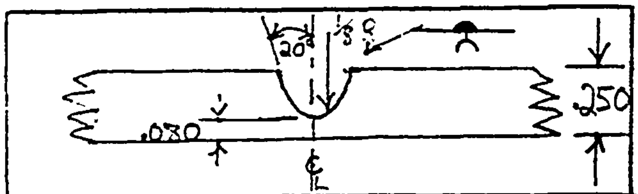
PACIFIC SHIPYARDS CORPORATION

TODD

SEATTLE DIVISION

WELDING PROCEDURE QUALIFICATION TEST SUMMARY

TEST SERIES NO. D-8
PROCEDURE NO.
PROCESS GMAW
CONTRACT MARAD SP-7
DATE 12/1/83



QUALIFICATION JOINT

MATERIALS:

BASE SPEC. QQ-A-250/19
5086 H116
MATL. THICKNESS .250"
FILLER SPEC. AWS A5.10-80
ER 5556
FILLER DIA. 3/64"
SHIELDING GAS 75% HE/25% AR
FLUX AND SIZE NA

EQUIPMENT:

POWER SUPPLY AIRCO PULSE ARC 350
TORCH OR HOLDER TYPE BINZEL
CUP TYPE & SIZE METALLIC 3/4"
ELECTRODE TYPE & SIZE NA

OPERATING PARAMETERS:

WELDING POS. VERTICAL-UP NO. PASSES 1
PREHEAT 60° MIN. INTERPASS TEMP. NA
CURRENT CHARAC. DC RP
CURRENT RANGE 150
VOLTAGE RANGE 16
WIRE FEED IPM 362
SHIELD FLOW 40 CFH
TRAVEL SPEED 11.5 IPM
MAX. HEAT INPUT J/IN NA
HEAT TREAT NA
OTHER NA

NDT TESTS:

[x] VIS. [x] PT [ ] UT [x] RT [ ] MT

RESULTS:

Visual - No visible defects
P.T. Acceptable - Report # 1621 attached
R.T. Acceptable - Report # 7085 attached

DT TESTS:	PLATE OR SPEC. SER. NO.
[x] RST	Sat. Report # E28426-12
[ ] HRDNS	
[ ] CHARPY	
[ ] SIDE BEND	
[x] ROOT BEND	Sat. Report # E28426-12
[x] FACE BEND	Sat. Report # E28426-12
[ ] FILLET BEND	
[ ] FILLET BREAK	
[ ] TRANS.SHEAR	
[ ] LONG SHEAR	
[ ] EXPL.BULGE	
[ ] OTHER	

REMARKS:

J.H. HITCH *J H Hitch*	10879	J.C.JOHNSTON	
WELD OPR.	CLOCK NO.	TEST BY	QUAL. RANGE

THIS CERTIFIES THAT THE DATA HEREIN IS COMPLETE AND ACCURATE TO BEST POSSIBLE KNOWLEDGE AND THAT TESTING AND EVALUATION WAS CONDUCTED IN ACCORDANCE WITH THE REQUIREMENTS LISTED BELOW.

James C Johnston
WELDING ENGINEER DATE

TODD SHIPYARDS CORPORATION
SEATTLE DIVISION
QUALITY ASSURANCE DEPARTMENT

DATE 5-19-83

TODD ORDER NO. 4787 ITEM NO. 101.00 REPORT NO. 1621

DYE PENETRANT NONDESTRUCTIVE TEST REPORT

JOB DESCRIPTION

MARAD PLATE GMAW SHORT ARC PROCESS

FOR: TWPS No. D . 8	MATERIAL: Aluminum
PENETRANT EQUIP. DUBL-CHEK; VISIBLE RED	PENETRANT TIME: 15-20 min.
REPORTS TO: Distribution	DEVELOPMENT TIME: 7-30 min.

PER SPEC: MIL-STD-271 E , NAVSHIPS 0900-003-8000, CLASS I

CONTRACT NO. NNS POM 70200-R

Liquid penetrant inspection of weld was found to be acceptable.

QA-PT-

PENETRANT INSPECTOR B. Dyer
R. Bell

TODD
2
SEATTLE

Cable "Robin" New York

TODD SHIPYARDS CORPORATION

Seattle Division: 1801 16th Avenue, S.W. Seattle, Washington 98124 • 623-1635 (206)

REPORT NO. 7085
DATE 5-10-83

RADIOGRAPHIC INSPECTION REPORT-WELDMENTS-- CONTRACT NO. ______ HULL ______

JOB NAME TWPS JOB NO. 4767 ITEM NO. 10100 PAGE 1 of 1

DESCRIPTION MARAD PLT-6MAW SHORTARC MAT'L AL 114 QUANTITY 1

RSS NO. 11Q-001 A QUALITY LEVEL: 2-2T ☐ 2-4T ☐ --% RT: 100% ☒ 50% ☐ 10% ☐ SPOT ☐

MIL- STD-271-E ☒
NAVSHIPS 0900-003-9000, CLASS 1
ABS CLASS A ☐ CLASS B ☐
OTHER:

FILM TYPE(S)	SFD(INCHES)	THICKNESS (INCHES)	SEQUENCE NO.	VIEW	ORIG. or REP.	POROSITY	INCLUSIONS	INCOMPLETE PENETRATION	INCOMPLETE FUSION	CRACK	UNDERCUT	SURFACE	OTHER	DISPOSITION JOINT	ACCEPT	REJECT	REMARKS
4	30	114	.	0-1	O	1	1				1	1		# D8	X		

CODE
. ACCEPTABLE
. BORDERLINE
. EXCESSIVE

SINGLE FILM ☒
MULTIFILM ☐
BOTH ☐

RADIATION SOURCE:
X-RAY: KV 80 mA 2
IR-192: CURIES NA

NO. OF VIEWS	FILM SIZE AND QUANTITY			
	4½×17	4½×10		
1	2			

RADIOGRAPHER(S) MOORE/KROFTA

PREPARED BY [signature]

APPROVED BY R. Bell

ACCEPTED BY ______

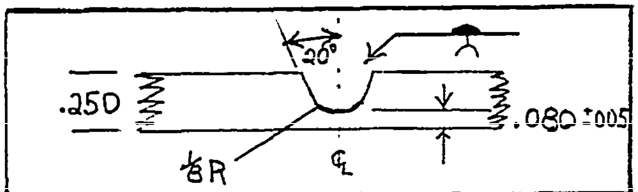
QA-RT-2

TODD PACIFIC SHIPYARDS CORPORATION

SEATTLE DIVISION

WELDING PROCEDURE QUALIFICATION TEST SUMMARY

TEST SERIES NO. D-10
PROCEDURE NO.
PROCESS GMAW
CONTRACT MARAD SP-7
DATE 12/1/83



QUALIFICATION JOINT

MATERIALS:
BASE SPEC. QQ-A-250/19
5086 H-116
MATL. THICKNESS .250"
FILLER SPEC. AWS A5.10-80
ER 5556
FILLER DIA. 3/64"
SHIELDING GAS HELIUM 100%
FLUX AND SIZE NA

EQUIPMENT:
POWER SUPPLY AIRCO PULSE ARC 350
TORCH OR HOLDER TYPE BINZEL
CUP TYPE & SIZE METALLIC 3/ 4"
ELECTRODE TYPE & SIZE NA

OPERATING PARAMETERS:
WELDING POS. HORIZONTAL NO. PASSES 1
PREHEAT 60° MIN. INTERPASS TEMP. NA
CURRENT CHARAC. DC RP
CURRENT RANGE 149
VOLTAGE RANGE 14.5
WIRE FEED IPM 327
SHIELD FLOW 100 CFH
TRAVEL SPEED 8.4 IPM
MAX. HEAT INPUT J/IN NA
HEAT TREAT NA
OTHER NA

NDT TESTS:
[X] VIS. [X] PT [ ] UT [X] RT [ ] MT

DT TESTS:	PLATE OR SPEC. SER. NO.
[X] RST	Sat. Report # E28635-3
[ ] HRDNS	
[ ] CHARPY	
[ ] SIDE BEND	
[X] ROOT BEND	Sat. Report # E28635-3
[X] FACE BEND	Sat. Report # E28635-3
[ ] FILLET BEND	
[ ] FILLET BREAK	
[ ] TRANS. SHEAR	
[ ] LONG SHEAR	
[ ] EXPL. BULGE	
[ ] OTHER	

RESULTS:
Visual - No visible defects
P.T. Acceptable - Report # 1649 attached
R.T. Acceptable - Report # 7106 attached

REMARKS:

JON H. HITCH *J H Hitch* 10879 JAMES C. JOHNSTON
WELD OPR. CLOCK NO. TEST BY QUAL. RANGE

THIS CERTIFIES THAT THE DATA HEREIN IS COMPLETE AND ACCURATE TO BEST POSSIBLE KNOWLEDGE AND THAT TESTING AND EVALUATION WAS CONDUCTED IN ACCORDANCE WITH THE REQUIREMENTS LISTED BELOW.

James C Johnston
WELDING ENGINEER DATE

TODD SHIPYARDS CORPORATION
SEATTLE DIVISION
QUALITY ASSURANCE DEPARTMENT

DATE 6-10-83

TODD ORDER NO. 4787 . ITEM NO. 101.00 REPORT NO. 1649

DYE PENETRANT NONDESTRUCTIVE TEST REPORT

JOB DESCRIPTION MARAD PLATE GMAW SHORT ARC PROCESS	
FOR: TWPS No. D - 10	MATERIAL: Aluminum
PENETRANT EQUIP. DUBL-CHEK; VISIBLE RED	PENETRANT TIME: 15-20 min.
REPORTS TO: Distribution	DEVELOPMENT TIME: 7-30 min.
PER SPEC: MIL-STD-271 E , NAVSHIPS 0900-003-8000, CLASS I	

CONTRACT NO. NNS POM70200-R

Liquid penetrant inspection of weld was found to be acceptable.

PENETRANT INSPECTOR B. Dyer
R. Bell

QA-PT-

Cable "Robin" New York

TODD SHIPYARDS CORPORATION

Seattle Division: 1801 16th Avenue, S.W. Seattle, Washington 98124 • 623-1635 (206)

REPORT NO. 2106
DATE 6-7-73
HULL 1-A

:ADIOGRAPHIC INSPECTION REPORT-WELDMENTS-- CONTRACT NO. ____

OB NAME TWPS JOB NO. 4787 ITEM NO. 10100 PAGE 1 of 1

IESCRIPTION MARAD PLT-GMAW SHORT ARC MAT'L AL 1/4" QUANTITY 1

ISS NO. WQ-001-A QUALITY LEVEL: 2-2T ☒ 2-4T ☐ --% RT: 100% ☒ 50% ☐ 10% ☐ SPOT ☐

MIL- STD-271-E ☒
NAVSHIPS 0900-003-9000, CLASS 1
ABS CLASS A ☐ CLASS B ☐
OTHER:

FILM TYPE(S)	SFD(INCHES)	THICKNESS (INCHES)	SEQUENCE NO.	VIEW	ORIG. or REP.	POROSITY	INCLUSIONS	INCOMPLETE PENETRATION	INCOMPLETE FUSION	CRACK	UNDERCUT	SURFACE	OTHER	DISPOSITION: JOINT	DISPOSITION: ACCEPT	DISPOSITION: REJECT	REMARKS
4	30	1/4	.	0-1	O	1					1	1		D.10	X		

CODE
ACCEPTABLE
BORDERLINE
EXCESSIVE

SINGLE FILM ☐
MULTIFILM ☐
BOTH ☒

RADIATION SOURCE:
X-RAY: KV 80 mA 2
IR-192: CURIES 1/4

NO. OF VIEWS	FILM SIZE AND QUANTITY: 4½×17	4½×10		
1	2			

RADIOGRAPHER(S) MOORE / KROFTA

PREPARED BY [signature]

APPROVED BY R. Bell

ACCEPTED BY ____

QA-RT-2

TODD SHIPYARDS CORPORATION
SEATTLE DIVISION
QUALITY ASSURANCE DEPARTMENT

DATE 5-10-83

TODD ORDER NO. 4787 . ITEM NO. 101.00 REPORT NO. 1608

DYE PENETRANT NONDESTRUCTIVE TEST REPORT

JOB DESCRIPTION

MARAD PLATE GMAW SHORT ARC PROCESS

FOR: TWPS NO. E-7	MATERIAL: Aluminum
PENETRANT EQUIP. DUBL-CHEK; VISIBLE RED	PENETRANT TIME: 15-20min.
REPORTS TO: Distribution	DEVELOPMENT TIME: 7-30 min.
PER SPEC: MIL-STD-271 E , NAVSHIPS 0900-003-8000, CLASS I	

CONTRACT NO. NNS POM 70200-R

Liquid penetrant inspection of weld was found to be acceptable.

PENETRANT INSPECTOR B. Dyer R. Bell

TODD SEATTLE

QA-PT-

Cable "Robin" New York

TODD SHIPYARDS CORPORATION

Seattle Division: 1801 16th Avenue, S.W. Seattle, Washington 98124 • 623-1635 (206)

REPORT NO. 7048
DATE 5/9/83

RADIOGRAPHIC INSPECTION REPORT-WELDMENTS-- CONTRACT NO. NNS POM 70200-R HULL N/A

JOB NAME TWPS No. E-7 JOB NO. 4787 ITEM NO. 101.00 PAGE 1 of 1

DESCRIPTION MARAD PLATE GMAW SHORT ARC PROCESS MAT'L Aluminum .250 QUANTITY 1

RSS NO. WQ-001-A QUALITY LEVEL: 2-2T [X] 2-4T [ ] --% RT: 100% [X] 50% [ ] 10% [ ] SPOT [ ]

MIL- STD-271-E [X]
NAVSHIPS 0900-003-9000, CLASS 1
ABS CLASS A [ ] CLASS B [ ]
OTHER:

FILM TYPE(S)	SFD (INCHES)	THICKNESS (INCHES)	SEQUENCE NO.	VIEW	ORIG. or REP.	POROSITY	INCLUSIONS	INCOMPLETE PENETRATION	INCOMPLETE FUSION	CRACK	UNDERCUT	SURFACE	OTHER	DISPOSITION JOINT E - 7	ACCEPT	REJECT	REMARKS
-4	30	.25	-	0-1	0	1	1				1	1	*	VERT UP	X		Prior to removal of weld rein-forcement
																	*Spatter

CODE
. ACCEPTABLE
. BORDERLINE
. EXCESSIVE

SINGLE FILM [X]
MULTIFILM [ ]
BOTH [ ]

RADIATION SOURCE:
X-RAY: KV 80 mA 2
IR-192: CURIES N/A

NO. OF VIEWS	FILM SIZE AND QUANTITY			
	4½×17	4½×10		
1	2			

PREPARED BY T. Moore

APPROVED BY R. D. Bee [stamp: TODD SEA X 1]

ACCEPTED BY

RADIOGRAPHER(S) T. Moore/C. Krofta

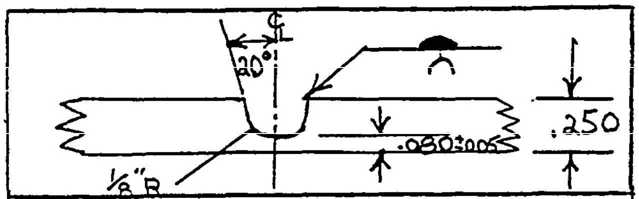
QA-RT-2

TODD PACIFIC SHIPYARDS CORPORATION

SEATTLE DIVISION

WELDING PROCEDURE QUALIFICATION TEST SUMMARY

TEST SERIES NO. E-33
PROCEDURE NO.
PROCESS GMAW
CONTRACT MARAD SP-7
DATE 12/1/83



QUALIFICATION JOINT

MATERIALS:
BASE SPEC. QQ-A-250/19
5456 H116
MATL. THICKNESS .250"
FILLER SPEC. AWS A5.10-80
ER 5556
FILLER DIA. 3/64 INCH
SHIELDING GAS 100% HELIUM
FLUX AND SIZE NA

EQUIPMENT:
POWER SUPPLY AIRCO PULSE ARC 350
TORCH OR HOLDER TYPE BINZEL
CUP TYPE & SIZE METALLIC 3/4"
ELECTRODE TYPE & SIZE NA

OPERATING PARAMETERS:
WELDING POS. HORIZONTAL NO. PASSES 1
PREHEAT 60° MIN. INTERPASS TEMP. NA
CURRENT CHARAC. DC RP
CURRENT RANGE 156
VOLTAGE RANGE 14.5
WIRE FEED IPM 343
SHIELD FLOW 100 CFH
TRAVEL SPEED 8.9 IPM
MAX. HEAT INPUT J/IN NA
HEAT TREAT NA
OTHER NA

NDT TESTS:

[x] VIS. [x] PT [ ] UT [x] RT [ ] MT

DT TESTS: PLATE OR SPEC. SER. NO.

	Test	Plate or Spec. Ser. No.
X	RST	Sat. Report # E28635-2
	HRDNS	
	CHARPY	
	SIDE BEND	
X	ROOT BEND	Sat. Report # E28635-2
X	FACE BEND	Sat. Report # E28635-2
	FILLET BEND	
	FILLET BREAK	
	TRANS. SHEAR	
	LONG SHEAR	
	EXPL. BULGE	
	OTHER	

RESULTS:
Visual - No visible defects
P.T. Acceptable - Report # 1650 attached
R.T. Acceptable - Report # 7109 attached

REMARKS:

JON H. HITCH *J H Hitch* 10879 JAMES C. JOHNSTON
WELD OPR. CLOCK NO. TEST BY QUAL. RANGE

THIS CERTIFIES THAT THE DATA HEREIN IS COMPLETE AND ACCURATE TO BEST POSSIBLE KNOWLEDGE AND THAT TESTING AND EVALUATION WAS CONDUCTED IN ACCORDANCE WITH THE REQUIREMENTS LISTED BELOW.

James C Johnston
WELDING ENGINEER DATE

TODD SHIPYARDS CORPORATION
SEATTLE DIVISION
QUALTY ASSURANCE DEPARTMENT

DATE 6-10-83

TODD ORDER NO. 4787 . ITEM NO. 101.00 REPORT NO. 1650

DYE PENETRANT NONDESTRUCTIVE TEST REPORT

JOB DESCRIPTION

MARAD PLATE GMAW SHORT ARC PROCESS

FOR: TWPS *NO.* E -33	MATERIAL: AIuminum
PENETRANT EQUIP. DUBL-CHEK; ,VISIBLE RED	PENETRANT TIME: 15-20 min.
REPORTS TO: Distribution	DEVELOPMENT TIME: 7-30 min.

PER SPEC: MIL-STD-271 E , NAVSHIPS 0900-003-8000, CLASS I

CONTRACT NO. NNS POM 70200-R

Liquid penetrant inspection of weld was found to.be acceptable.

QA-PT

PENETRANT INSPECTOR B. Dyer R. Bell

Cable "Robin" New York

TODD SHIPYARDS CORPORATION

Seattle Division: 1801 16th Avenue, S.W. Seattle, Washington 98124 • 623-1635 (206)

REPORT NO. 2109
DATE 6-8-83
HULL N/A

RADIOGRAPHIC INSPECTION REPORT-WELDMENTS-- CONTRACT NO. ______

JOB NAME TWPS JOB NO. 4787 ITEM NO. 10100 PAGE 1 of 1

DESCRIPTION MARAD PLT-6MAW SHORTARC MAT'L AL 1/4" QUANTITY 1

RSS NO. 1010-001A QUALITY LEVEL: 2-2T ☒ 2-4T ☐ --% RT: 100% ☒ 50% ☐ 10% ☐ SPOT ☐

FILM TYPE(S)	SFD(INCHES)	THICKNESS (INCHES)	SEQUENCE NO.	VIEW	ORIG. or REP.	POROSITY	INCLUSIONS	INCOMPLETE PENETRATION	INCOMPLETE FUSION	CRACK	UNDERCUT	SURFACE	OTHER	DISPOSITION JOINT	ACCEPT	REJECT	REMARKS
4	30	1/4	.	0-1	O	1					1	1		E33	X		

MIL- STD-271-E ☒
NAVSHIPS 0900-003-9000,CLASS 1
ABS CLASS A ☐ CLASS B ☐
OTHER:

CODE
1. ACCEPTABLE
2. BORDERLINE
3. EXCESSIVE

SINGLE FILM ☒
MULTIFILM ☐
BOTH ☐

RADIATION SOURCE:
X-RAY: KV 80 mA 2
IR-192: CURIES N/A

NO. OF VIEWS	FILM SIZE AND QUANTITY			
	4½×17	4½×10		
1	2			

RADIOGRAPHER(S) MOORE / KROFTA

PREPARED BY [signature]

APPROVED BY R. Bell

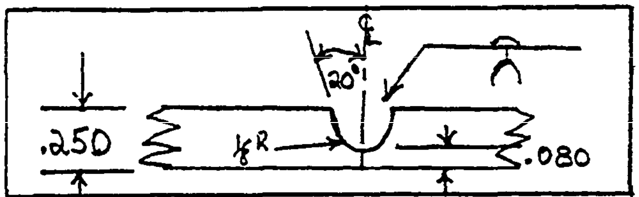
ACCEPTED BY ______

TODD SEA 1

QA-RT-2

TODD PACIFIC SHIPYARDS CORPORATION
SEATTLE DIVISION
WELDING PROCEDURE QUALIFICATION TEST SUMMARY

TEST SERIES NO. F-3
PROCEDURE NO.
PROCESS GMAW
CONTRACT MARAD SP-7
DATE 12/1/83



QUALIFICATION JOINT

MATERIALS:
BASE SPEC. QQ-A-250/6
5083 H-321
MATL. THICKNESS .250"
FILLER SPEC. AWS A5.10-80
ER 5556
FILLER DIA. 3/64"
SHIELDING GAS 75% HE/25% AR
FLUX AND SIZE NA
EQUIPMENT:
POWER SUPPLY AIRCO PULSE ARC 350
TORCH OR HOLDER TYPE BINZEL
CUP TYPE & SIZE METALLIC 3/4"
ELECTRODE TYPE & SIZE NA

OPERATING PARAMETERS:
WELDING POS. VERTICAL-UP NO. PASSES 1
PREHEAT 60° MIN. INTERPASS TEMP. NA
CURRENT CHARAC. DC RP
CURRENT RANGE 130
VOLTAGE RANGE 15.7
WIRE FEED IPM 330
SHIELD FLOW 40 CFH
TRAVEL SPEED 12 IPM
MAX. HEAT INPUT J/IN
HEAT TREAT NA
OTHER NA

NDT TESTS:
[X] VIS. [X] PT [ ] UT [X] RT [ ] MT

DT TESTS:

	PLATE OR SPEC. SER. NO.
[X] RST	Sat. Report # E28426-14
[ ] HRDNS	
[ ] CHARPY	
[ ] SIDE BEND	
[X] ROOT BEND	Sat. Report # E28426-14
[X] FACE BEND	Sat. Report # E28426-14
[ ] FILLET BEND	
[ ] FILLET BREAK	
[ ] TRANS. SHEAR	
[ ] LONG SHEAR	
[ ] EXPL. BULGE	
[ ] OTHER	

RESULTS:
Visual - No visible defects
P.T. Acceptable - Report # 1622 attached
R.T. Acceptable - Report # 7087 attached

REMARKS:

J.H. HITCH J H Hitch 10879 J.C. JOHNSTON
WELD OPR. CLOCK NO. TEST BY QUAL. RANGE

THIS CERTIFIES THAT THE DATA HEREIN IS COMPLETE AND ACCURATE TO BEST POSSIBLE KNOWLEDGE AND THAT TESTING AND EVALUATION WAS CONDUCTED IN ACCORDANCE WITH THE REQUIREMENTS LISTED BELOW.

James C Johnston
WELDING ENGINEER DATE

TODD SHIPYARDS CORPORATION
SEATTLE DIVISION
QUALITY ASSURANCE DEPARTMENT

DATE 5-19-83

TODD ORDER NO. 4787 ITEM NO. 101.00 REPORT NO. 1622

DYE PENETRANT NONDESTRUCTIVE TEST REPORT

JOB DESCRIPTION

MARAD PLATE GMAW SHORT ARC PROCESS

FOR: TWPS No. F . 3	MATERIAL: Aluminum
PENETRANT EQUIP. DUBL-CHEK; VISIBLE RED	PENETRANT TIME: 15-20 min.
REPORTS TO: Distribution	DEVELOPMENT TIME: 7-30 min.
PER SPEC: MIL-STD-271 E , NAVSHIPS 0900-003-8000, CLASS I	

CONTRACT NO. NNW POM 70200-R

Liquid penetrant inspection of weld was found to be acceptable.

PENETRANT INSPECTOR B. Dyer
R. Bell

QA-PT-

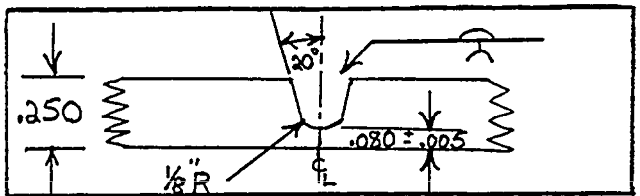
TODD
2
SEATTLE

TODD PACIFIC SHIPYARDS CORPORATION

SEATTLE DIVISION

WELDING PROCEDURE QUALIFICATION TEST SUMMARY

TEST SERIES NO. F-13
PROCEDURE NO.
PROCESS GMAW
CONTRACT MARAD SP-7
DATE 12/1/83



QUALIFICATION JOINT

MATERIALS:

BASE SPEC. QQ-A-250/6
5083 H321
MATL. THICKNESS .250"
FILLER SPEC. AWS A5.10-80
ER 5556
FILLER DIA. 3/64"
SHIELDING GAS HELIUM 100%
FLUX AND SIZE NA

EQUIPMENT:

POWER SUPPLY AIRCO PA 350
TORCH OR HOLDER TYPE BINZEL
CUP TYPE & SIZE METALLIC 3/4"
ELECTRODE TYPE & SIZE NA

OPERATING PARAMETERS:

WELDING POS. HORIZONTAL NO. PASSES 1
PREHEAT 60° MIN. INTERPASS TEMP. NA
CURRENT CHARAC. DC RP
CURRENT RANGE 145
VOLTAGE RANGE 14.5
WIRE FEED IPM 333
SHIELD FLOW 100 CFH
TRAVEL SPEED 10.2 IPM
MAX. HEAT INPUT J/IN NA
HEAT TREAT NA
OTHER NA

NDT TESTS:

[X] VIS. [X] PT [ ] UT [X] RT [ ] MT

RESULTS:

Visual - No visible defects

P.T. Acceptable - Report # 1648 attached

R.T. Acceptable - Report # 7111 attached

DT TESTS:

	DT TESTS	PLATE OR SPEC. SER. NO.
X	RST	Sat. Report # E28635-1
	HRDNS	
	CHARPY	
	SIDE BEND	
X	ROOT BEND	Sat. Report # E28635-1
X	FACE BEND	Sat. Report # E28635-1
	FILLET BEND	
	FILLET BREAK	
	TRANS. SHEAR	
	LONG SHEAR	
	EXPL. BULGE	
	OTHER	

REMARKS:

JON H. HITCH J H Hitch 10879 JAMES C. JOHNSTON
WELD OPR. CLOCK NO. TEST BY QUAL. RANGE

THIS CERTIFIES THAT THE DATA HEREIN IS COMPLETE AND ACCURATE TO BEST POSSIBLE KNOWLEDGE AND THAT TESTING AND EVALUATION WAS CONDUCTED IN ACCORDANCE WITH THE REQUIREMENTS LISTED BELOW.

James C Johnston
WELDING ENGINEER DATE

TODD SHIPYARDS CORPORATION
SEATTLE DIVISION
QUALITY ASSURANCE DEPARTMENT

DATE 6-10-83

TODD ORDER NO. 4787 . ITEM No. 101.00 REPORT NO. 1648

DYE PENETRANT NONDESTRUCTIVE TEST REPORT

JOB DESCRIPTION MARAD PLATE GMAW SHORT ARC PROCESS	
FOR: TWPS No. F -13	MATERIAL: Aluminum
PENETRANT EQUIP. DUBL-CHEK; VISIBLE RED	PENETRANT TIME: 15-20 min.
REPORTS TO: Distribution	DEVELOPMENT TIME: 7-30 min.
PER SPEC: MIL-STD-271 E, NAVSHIPS 0900-003-8000 CLASS I	

CONTRACT NO. NNS POM 70200-R

Liquid penetrant inspection of weld was found to be acceptable.

QA-PT.

PENETRANT INSPECTOR B. Dyer
R. Bell

Cable "Robin" New York

TODD SHIPYARDS CORPORATION

Seattle Division: 1801 16th Avenue, S.W. Seattle, Washington 98124 • 623-1635 (206)

REPORT NO. 7111

DATE 6-7-73

RADIOGRAPHIC INSPECTION REPORT-WELDMENTS-- CONTRACT NO. ______ HULL NA

JOB NAME TWPS JOB NO. 4787 ITEM NO. 10100 PAGE 1 of 1

DESCRIPTION MARAD PLT - 6 MAIN SHORT ARC MAT'L AL 1/4" QUANTITY 1

PSS NO. 1120-001A QUALITY LEVEL: 2-2T ☒ 2-4T ☐ --% RT: 100% ☒ 50% ☐ 10% ☐ SPOT ☐

FILM TYPE(S)	SFD(INCHES)	THICKNESS (INCHES)	SEQUENCE NO.	VIEW	ORIG. or REP.	POROSITY	INCLUSIONS	INCOMPLETE PENETRATION	INCOMPLETE FUSION	CRACK	UNDERCUT	SURFACE	OTHER	DISPOSITION JOINT F13	ACCEPT	REJECT	REMARKS
1	30	1/4	.	0-1	0	1					1	1			X		

MIL- STD-271-E ☐

NAVSHIPS 0900-003-9000, CLASS 1

ABS CLASS A ☐ CLASS B ☐

OTHER:

CODE

1. ACCEPTABLE
2. BORDERLINE
3. EXCESSIVE

SINGLE FILM ☒

MULTIFILM ☐

BOTH ☐

RADIATION SOURCE:

X-RAY: KV 80 mA 2

IR-192: CURIES NA

NO. OF VIEWS	FILM SIZE AND QUANTITY			
	4½×17	4½×10		
1	2			

PREPARED BY [signature]

APPROVED BY R. Bell

ACCEPTED BY ______

RADIOGRAPHER(S) MOORE / KROFTA

QA-RT-2

MECHANIZED PULSE ARC WELDING : FLAT POSITION

5083 H-321 ALUMINUM ALLOY PLATE: .500 INCH THICKNESS ER 5356 ALUMINUM ALLOY FILLER WIRE; MILLER PULSTAR 450

Mechanized flat position, one-side, full penetration gas metal arc butt welding of .500 inch thick 5083 H-321, QQ-A-250/6 was accomplished with the use of a "BUG-O" tractor, Model 2000, with a post-mounted Airco AH 35-C2 water cooled torch. An Airco AHF-NP feeder was used in conjunction with a Miller Pulstar 450. The welding filler wire was 3/64 inch diameter 5356 aluminum alloy. Shielding gas used was 75% helium/25% argon. Acceptable non-destructive test results and mechanical properties data were attained. Weld procedure qualification data and specific welding machine settings are reported in their respective sections. A typical mechanized pulse arc welding set-up for flat position welding is illustrated in Figure 56. A mechanized pulse arc welding of test panel is shown in Figure 57. A mechanized pulse arc welding root bead in .500 inch thick 5083 H-321 aluminum alloy plates is illustrated in Figure 58. Weld bead surfaces and also under-beads are shown in Figures 59 and 60.

A limited number of .063 to .250 inch thick 5000 series aluminum alloy materials were butt welded into test panels with the use of mechanized pulse gas metal arc welding in the flat position. These panels were subsequently non-destructively inspected per the penetrant and radiographic test requirements exclusively, i.e. without destructive testing for mechanical properties. Acceptable machine settings which were established with the use of other pulse GMAW welding power sources and accessories are covered in the following section entitled "Pulse Arc Weld Machine Settings".

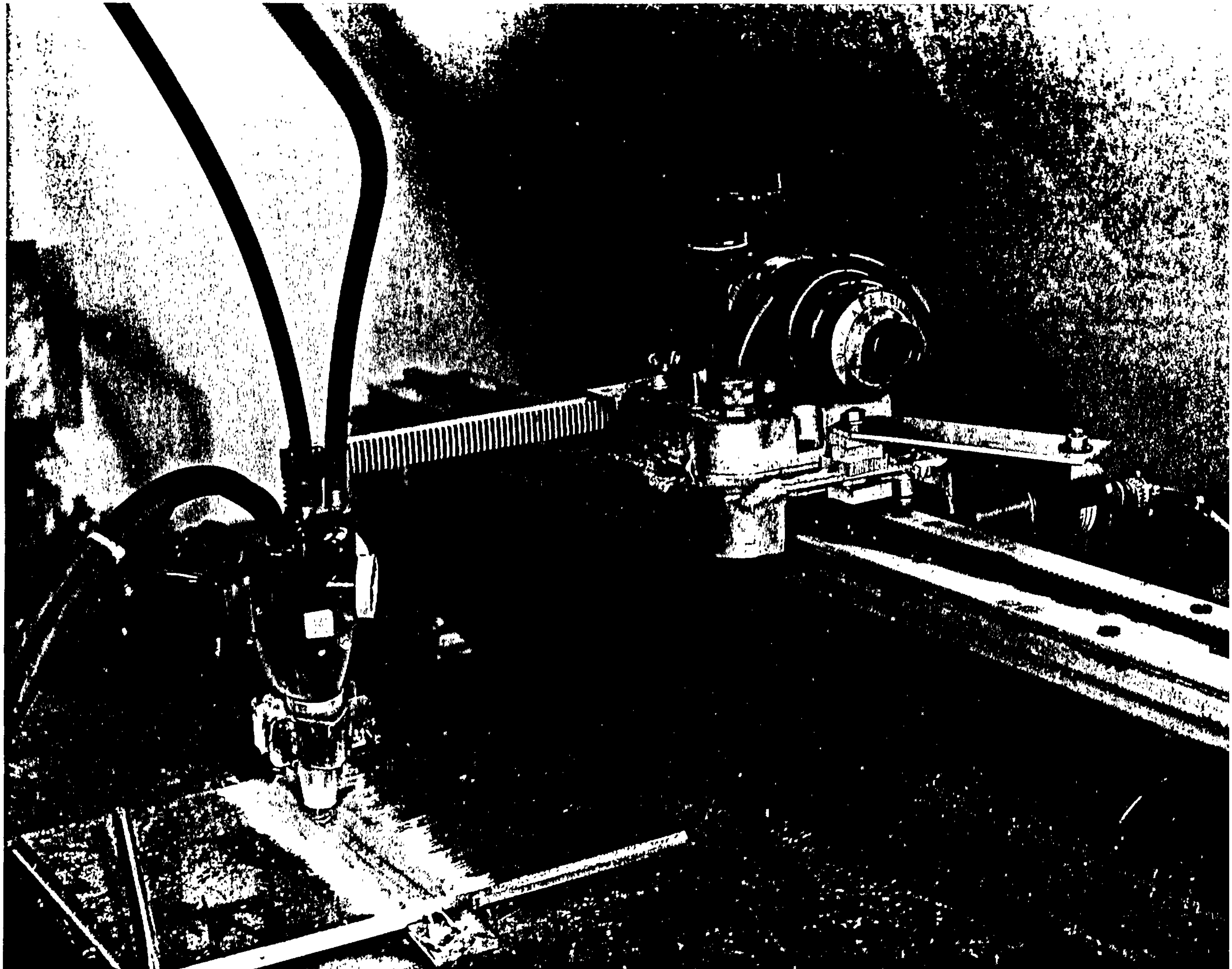


FIGURE 56
TYPICAL MECHANIZED PULSE ARC WELDING SET-UP: FLAT POSITION, ONE-SIDE, FULL PENETRATION BUTT WELDS

FIGURE 57
TYPICAL MECHANIZED PULSE ARC WELDING

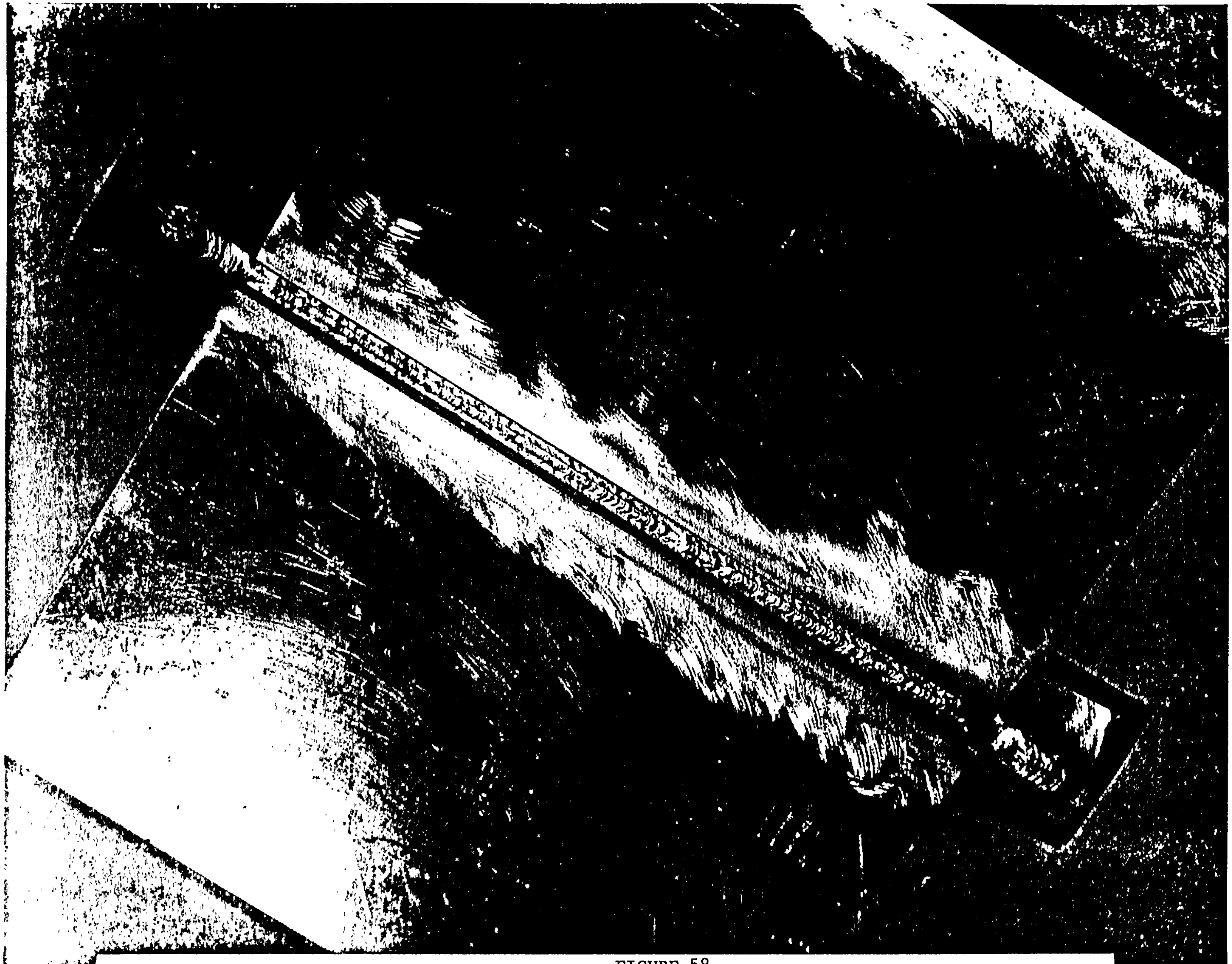


FIGURE 58
MECHANIZED PULSE ARC WELDED ROOT WELD BEAD: .500 INCH THICK 5086-H116 ALUMINUM ALLOY PLATE

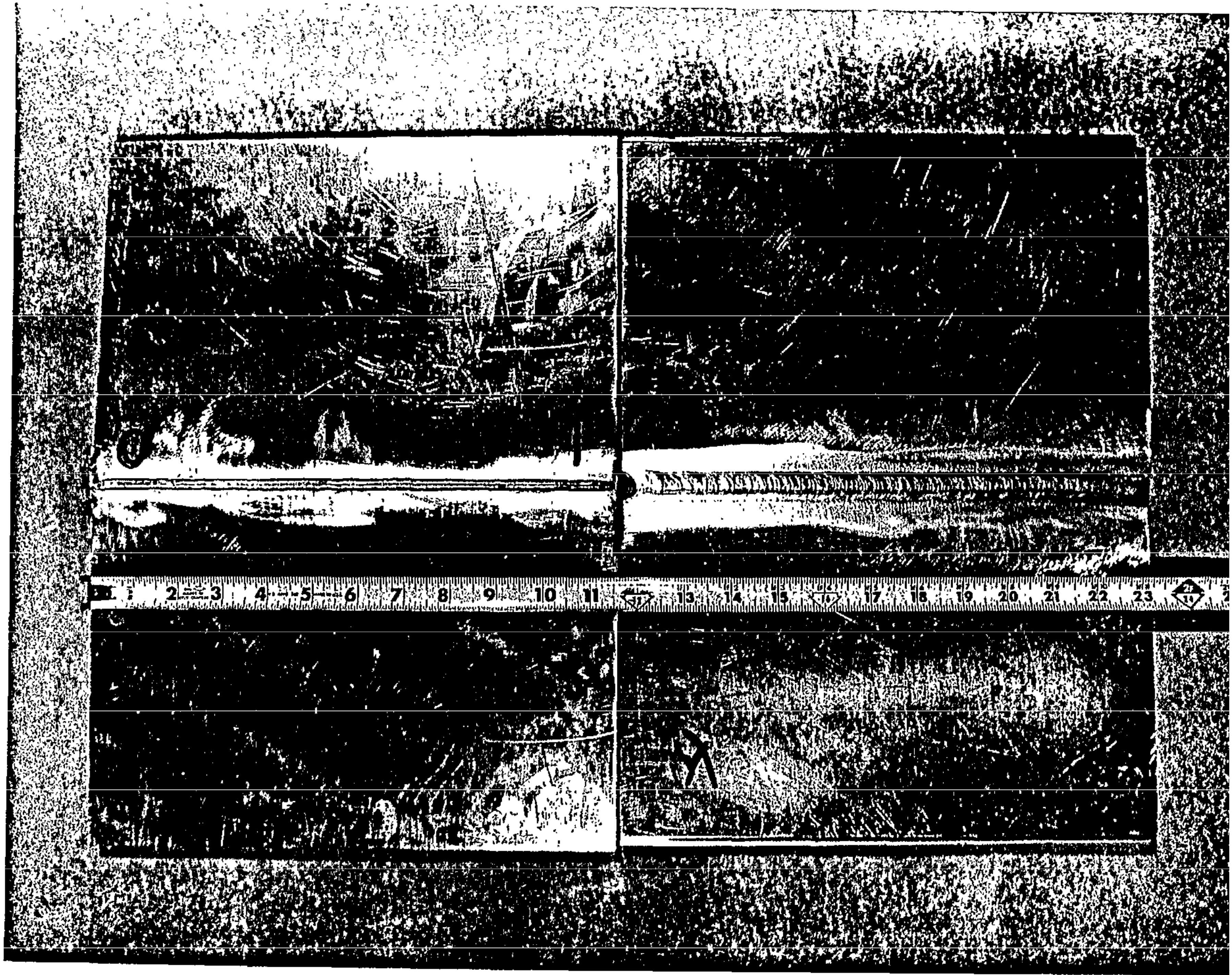


FIGURE 59
MECHANIZED PULSE ARC WELDED .500 INCH THICK 5086-H321 ALUMINUM ALLOY PLATE: UNDER-BEAD & SURFACE REINFORCEMENTS

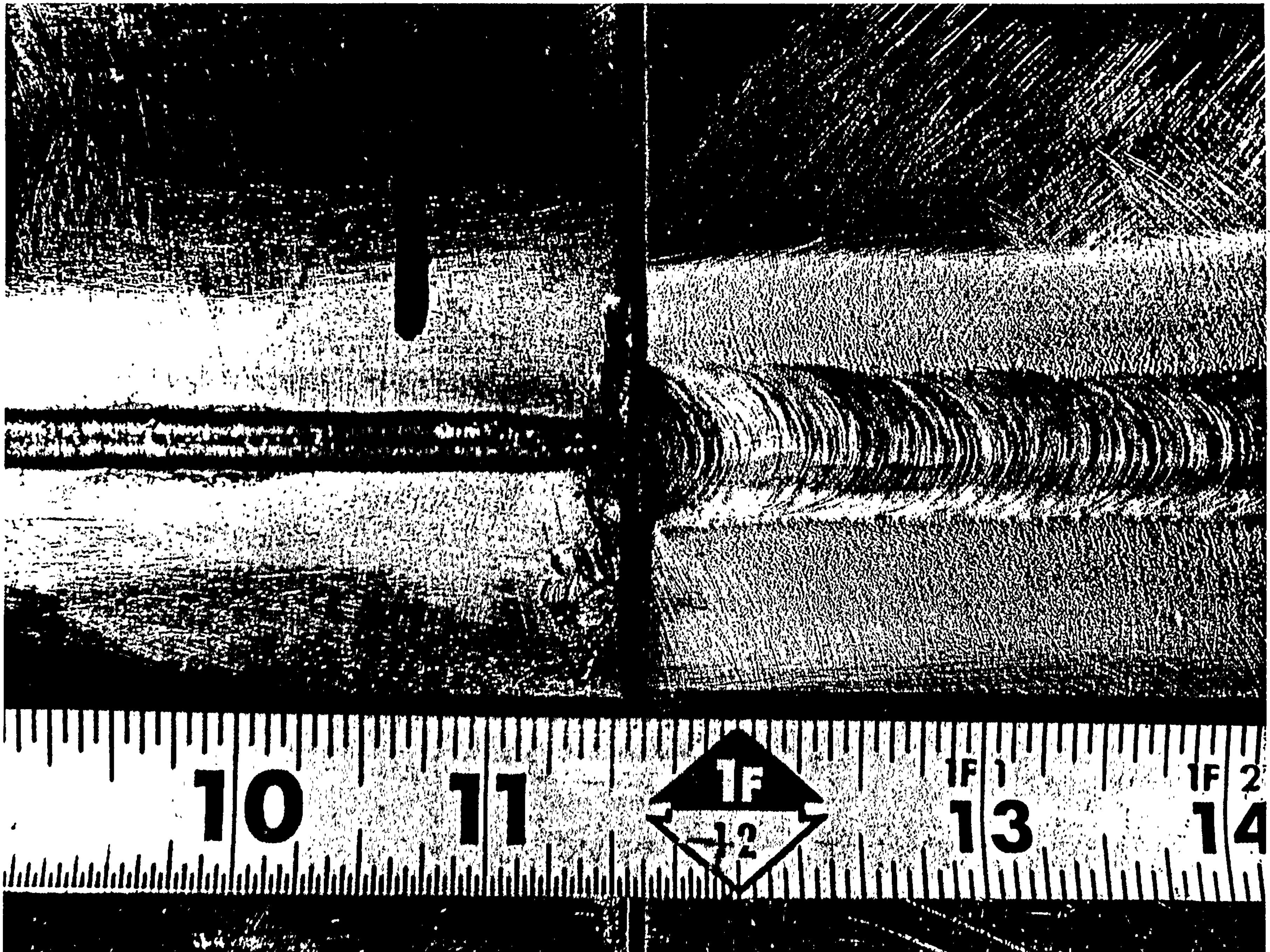


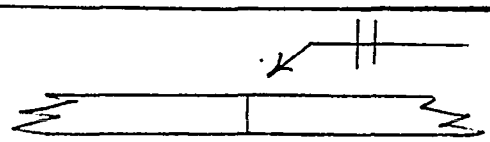
FIGURE 60
CLOSE-UP OF MECHANIZED PULSE ARC WELDED .500 INCH THICK 5083-H321 ALUMINUM ALLOY PLATE:
UNDER-BEAD AND SURFACE REINFORCEMENTS

PACIFIC SHIPYARDS CORPORATION

SEATTLE DIVISION

WELDING PROCEDURE QUALIFICATION TEST SUMMARY

TEST SERIES NO. A1.34
PROCEDURE NO.
PROCESS GMAW
CONTRACT MARAD SP-7
DATE 12/1/83



QUALIFICATION JOINT

MATERIALS:
BASE SPEC. 5086 H-32
QQ-A-150/7
MATL. THICKNESS .063"
FILLER SPEC. AWS A5.10-80
ER 5356
FILLER DIA. 3/64"
SHIELDING GAS 75% HE/25% AR
FLUX AND SIZE NA

EQUIPMENT:
POWER SUPPLY GILLILAND CV 600 FI-PA
TORCH OR HOLDER TYPE MTG 4001
CUP TYPE & SIZE METALLIC 3/4" ORIFICE
ELECTRODE TYPE & SIZE NA

OPERATING PARAMETERS:
WELDING POS. FLAT NO. PASSES 1
PREHEAT 60 F MIN. INTERPASS TEMP. NA
CURRENT CHARAC. DCRP
CURRENT RANGE 50
VOLTAGE RANGE 13.5
WIRE FEED IPM 130
SHIELD FLOW 40 CFH
TRAVEL SPEED 24.5 IPM
MAX. HEAT INPUT J/IN NA
HEAT TREAT NA
OTHER "BUG-O" CARRIAGE WITH POST MOUNTED TORCH 60 PPS

NDT TESTS:

[X] VIS. [X] PT [ ] UT [X] RT [ ] MT

DT TESTS: PLATE OR SPEC. SER. NO.

[ ] RST
[ ] HRDNS
[ ] CHARPY
[ ] SIDE BEND
[ ] ROOT BEND
[ ] FACE BEND
[ ] FILLET BEND
[ ] FILLET BREAK
[ ] TRANS. SHEAR
[ ] LONG SHEAR
[ ] EXPL. BULGE
[ ] OTHER

RESULTS:
Visual - No visible defects

P.T. Acceptable - Report # 1861 attached

R.T. Acceptable - Report # 7220 attached

REMARKS:

J.H. HITCH *J H Hitch* 10879 J.C. JOHNSTON
WELD OPR. CLOCK NO. TEST BY QUAL. RANGE

THIS CERTIFIES THAT THE DATA HEREIN IS COMPLETE AND ACCURATE TO BEST POSSIBLE KNOWLEDGE AND THAT TESTING AND EVALUATION WAS CONDUCTED IN ACCORDANCE WITH THE REQUIREMENTS LISTED BELOW.

James C. Johnston
WELDING ENGINEER DATE

TODD SHIPYARDS CORPORATION
SEATTLE DIVISION
QUALITY ASSURANCE DEPARTMENT

DATE 11-21-83

TODD ORDER NO. 4787 ITEM NO. 101.00 REPORT NO. 1861

DYE PENETRANT NONDESTRUCTIVE TEST REPORT

JOB DESCRIPTION

MARAD PLATE GMAW PULSED ARC PROCESS

FOR: TWPS No. A1.34, B.77, C.65, C.67	MATERIAL: Aluminum
PENETRANT EQUIP. DUBL-CHEK; VISIBLE RED	PENETRANT TIME: 15-20 min.
REPORTS TO: Distribution	DEVELOPMENT TIME: 7-30 min.
PER SPEC: MIL-STD-271 E , NAVSHIPS 0900-003-8000, CLASS I	

CONTRACT NO. NNS POM 70200-R

Liquid penetrant inspection of weld was found to be acceptable, for each plate.

QA-PT-

PENETRANT INSPECTOR T. Moore

Cable "Robin" New York

TODD SHIPYARDS CORPORATION

Seattle Division: 1801 16th Avenue, S.W. Seattle, Washington 98124 • 623-1635 (206)

REPORT NO. 7220

DATE 11-21-83

ADIOGRAPHIC INSPECTION REPORT-WELDMENTS-- CONTRACT NO. NNS DOM 70200-R HULL N/A

IB NAME MARAD R & D PROJECT JOB NO. 4787 ITEM NO. 101.00 PAGE 1 of 1

ESCRIPTION PROCEDURE PLATES MAT'L ALUM QUANTITY 4

SS NO. S-A-1 QUALITY LEVEL: 2-2T ☒ 2-4T ☐ --% RT: 100% ☒ 50% ☐ 10% ☐ SPOT ☐

MIL- STD-271-E ☒
NAVSHIPS 0900-003-9000, CLASS 1
ABS CLASS A ☐ CLASS B ☐
OTHER:

FILM TYPE(S)	SFD (INCHES)	THICKNESS (INCHES)	SEQUENCE NO.	VIEW	ORIG. or REP.	POROSITY	INCLUSIONS	INCOMPLETE PENETRATION	INCOMPLETE FUSION	CRACK	UNDERCUT	SURFACE	OTHER	DISPOSITION: JOINT	ACCEPT	REJECT	REMARKS
1	30	.063	-	0-1	0		1				1	1		A1-34	X		
		.100	-	0-1	0	1	1				1	1		B-77	X		
		.125	-	0-1	0						1	1		C-65	X		
		.125	-	0-1	0	1					1	1		C-67	X		

CODE
ACCEPTABLE
BORDERLINE
EXCESSIVE

SINGLE FILM ☒
MULTIFILM ☐
BOTH ☐

RADIATION SOURCE:
X-RAY: KV 100 mA 1.2
IR-192: CURIES N/A

NO. OF VIEWS	FILM SIZE AND QUANTITY			
	4½×17	4½×10		
4	4			

RADIOGRAPHER(S) T. MOORE

PREPARED BY R. Bell

APPROVED BY R. Bell

ACCEPTED BY

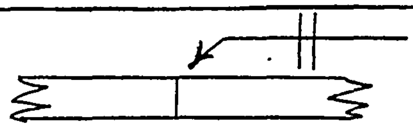
PACIFIC SHIPYARDS CORPORATION

TODD

SEATTLE DIVISION

WELDING PROCEDURE QUALIFICATION TEST SUMMARY

TEST SERIES NO. B.77
PROCEDURE NO.
PROCESS GMAW
CONTRACT MARAD SP-7
DATE 12/1/83



QUALIFICATION JOINT

MATERIALS:
BASE SPEC. QQ-A-150/7
5086 H-32
MATL. THICKNESS .100"
FILLER SPEC. AWS A5.10-80
ER 5356
FILLER DIA. 3/64"
SHIELDING GAS 75% HE/25% AR
FLUX AND SIZE NA

EQUIPMENT:
POWER SUPPLY GILLILAND CV 600 FI-PA
TORCH OR HOLDER TYPE MTG 4001
CUP TYPE & SIZE 3/4" METALLIC ORIFICE
ELECTRODE TYPE & SIZE NA

OPERATING PARAMETERS:
WELDING POS. FLAT NO. PASSES 1
PREHEAT 60 F MIN. INTERPASS TEMP. NA
CURRENT CHARAC. DCRP
CURRENT RANGE 60
VOLTAGE RANGE 16.5
WIRE FEED IPM 150
SHIELD FLOW 40 CFH
TRAVEL SPEED 22 IPM
MAX. HEAT INPUT J/IN NA
HEAT TREAT NA
OTHER "BUG-O" CARRIAGE WITH POST MOUNTED TORCH
60 PPS

NDT TESTS:

[x] VIS. [x] PT [ ] UT [x] RT [ ] MT

DT TESTS: PLATE OR SPEC. SER. NO.

- [ ] RST
- [ ] HRDNS
- [ ] CHARPY
- [ ] SIDE BEND
- [ ] ROOT BEND
- [ ] FACE BEND
- [ ] FILLET BEND
- [ ] FILLET BREAK
- [ ] TRANS. SHEAR
- [ ] LONG SHEAR
- [ ] EXPL. BULGE
- [ ] OTHER

RESULTS:
Visual - No visible defects

P.T. Acceptable - Report # 1861 attached

R.T. Acceptable - Report # 7220 attached

REMARKS:

J.H. HITCH	10879	J.C.JOHNSTON	
WELD OPR.	CLOCK NO.	TEST BY	QUAL. RANGE

THIS CERTIFIES THAT THE DATA HEREIN IS COMPLETE AND ACCURATE TO BEST POSSIBLE KNOWLEDGE AND THAT TESTING AND EVALUATION WAS CONDUCTED IN ACCORDANCE WITH THE REQUIREMENTS LISTED BELOW.

James C Johnston
WELDING ENGINEER DATE

TODD SHIPYARDS CORPORATION
SEATTLE DIVISION
QUALITY ASSURANCE DEPARTMENT

DATE 11-21-83

TODD ORDER NO. 4787 ITEM NO. 101.00 REPORT NO. 1861

DYE PENETRANT NONDESTRUCTIVE TEST REPORT

JOB DESCRIPTION

MARAD PLATE GMAW PULSED ARC PROCESS

FOR: TWPS No. A1.34, B.77, C.65, C.67	MATERIAL: Aluminum
PENETRANT EQUIP. DUBL-CHEK; VISIBLE RED	PENETRANT TIME: 15-20 min.
REPORTS TO: Distribution	DEVELOPMENT TIME: 7-30 min.

PER SPEC: MIL-STD-271 E, NAVSHIPS 0900-003-8000, CLASS I

CONTRACT NO. NNS POM 70200-R

Liquid penetrant inspection of weld was found to be acceptable, for each plate.

PENETRANT INSPECTOR T. Moore

QA-PT-

Cable "Robin" New York

TODD SHIPYARDS CORPORATION

Seattle Division: 1801 16th Avenue, S.W. Seattle, Washington 98124 • 623-1635 (206)

REPORT NO. 7220
DATE 11-21-7?

[R]ADIOGRAPHIC INSPECTION REPORT-WELDMENTS-- CONTRACT NO. NNS DOM 70200-R HULL N/A

[JO]B NAME MARAD R & D PROJECT JOB NO. 4787 ITEM NO. 101.00 PAGE 1 o[f]

[DE]SCRIPTION PROCEDURE PLATES MAT'L ALUM QUANTITY 4

[PR]S NO. S-A-1 QUALITY LEVEL: 2-2T ☒ 2-4T ☐ --% RT: 100% ☒ 50% ☐ 10% ☐ SPOT ☐

MIL- STD-271-E ☒
NAVSHIPS 0900-003-9000, CLASS ____
ABS CLASS A ☐ CLASS B ☐
OTHER:

FILM TYPE(S)	SFD (INCHES)	THICKNESS (INCHES)	SEQUENCE NO.	VIEW	ORIG. or REP.	POROSITY	INCLUSIONS	INCOMPLETE PENETRATION	INCOMPLETE FUSION	CRACK	UNDERCUT	SURFACE	OTHER	DISPOSITION: JOINT	ACCEPT	REJECT	REMARKS
	30	.063	-	0-1	O		1				1	1		A1-34	X		
		.100	-	0-1	O	1	1				1	1		B-77	X		
		.125	-	0-1	O						1	1		C-65	X		
		.125	-	0-1	O	1					1	1		C-67	X		

CODE
[A]CCEPTABLE
BORDERLINE
EXCESSIVE

RADIATION SOURCE:
X-RAY: KV 100 mA 1.2
IR-192: CURIES NA

[S]INGLE FILM ☒
[M]ULTIFILM ☐
[B]OTH ☐

NO. OF VIEWS	FILM SIZE AND QUANTITY			
	4½×17	4½×10		
4	4			

[R]ADIOGRAPHER(S) T. MOORE

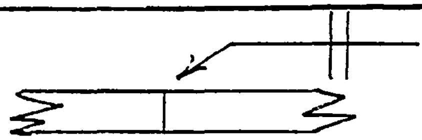
PREPARED BY R. BELL
APPROVED BY R. Bell
ACCEPTED BY ____

PACIFIC SHIPYARDS CORPORATION

SEATTLE DIVISION

WELDING PROCEDURE QUALIFICATION TEST SUMMARY

TEST SERIES NO. C.67, C.65
PROCEDURE NO.
PROCESS GMAW
CONTRACT MARAD SP-7
DATE 12/1/83



QUALIFICATION JOINT

MATERIALS:
BASE SPEC. 5083 H-323
QQ-A-250/7
MATL. THICKNESS .125"
FILLER SPEC. AWS A5.10-80
ER 5356
FILLER DIA. 3/64"
SHIELDING GAS 75%HE/25%AR
FLUX AND SIZE NA

EQUIPMENT:
POWER SUPPLY GILLILAND CV 600 FI-PA
TORCH OR HOLDER TYPE MTG 4001
CUP TYPE & SIZE 3/4" METALLIC ORIFICE
ELECTRODE TYPE & SIZE NA

OPERATING PARAMETERS:
WELDING POS. FLAT NO. PASSES 1
PREHEAT 60 F MIN. INTERPASS TEMP. NA
CURRENT CHARAC. DCRP
CURRENT RANGE 68
VOLTAGE RANGE 18.6
WIRE FEED IPM 175
SHIELD FLOW 40 CFH
TRAVEL SPEED 16.2 IPM
MAX. HEAT INPUT J/IN NA
HEAT TREAT NA
OTHER "BUG-O" CARRIAGE WITH POST MOUNTED TORCH. 60 PPS

NDT TESTS:

[x] VIS. [x] PT [ ] UT [x] RT [ ] MT

DT TESTS: PLATE OR SPEC. SER. NO.

- [ ] RST
- [ ] HRDNS
- [ ] CHARPY
- [ ] SIDE BEND
- [ ] ROOT BEND
- [ ] FACE BEND
- [ ] FILLET BEND
- [ ] FILLET BREAK
- [ ] TRANS.SHEAR
- [ ] LONG SHEAR
- [ ] EXPL.BULGE
- [ ] OTHER

RESULTS:
Visual - No visible defects

P.T. Acceptable - Report # 1861 attached

R.T. Acceptable - Report # 7220 attached

REMARKS:

J.H. HITCH *J H Hitch* 10879 J.C. JOHNSTON
WELD OPR. CLOCK NO. TEST BY QUAL. RANGE

THIS CERTIFIES THAT THE DATA HEREIN IS COMPLETE AND ACCURATE TO BEST POSSIBLE KNOWLEDGE AND THAT TESTING AND EVALUATION WAS CONDUCTED IN ACCORDANCE WITH THE REQUIREMENTS LISTED BELOW.

James C Johnston
WELDING ENGINEER DATE

TODD SHIPYARDS CORPORATION
SEATTLE DIVISION
QUALITY ASSURANCE DEPARTMENT

DATE 11-21-83

TODD ORDER NO. 4787 ITEM NO. 101.00 REPORT NO. 1861

DYE PENETRANT NONDESTRUCTIVE TEST REPORT

JOB DESCRIPTION

MARAD PLATE GMAW PULSED ARC PROCESS

FOR: TWPS No. A1.34, B.77, C.65, C.67	MATERIAL: Aluminum
PENETRANT EQUIP. DUBL-CHEK; VISIBLE RED	PENETRANT TIME: 15-20 min.
REPORTS TO: Distribution	DEVELOPMENT TIME: 7-30 min.
PER SPEC: MIL-STD-271 E , NAVSHIPS 0900-003-8000, CLASS I	

CONTRACT NO. NNS POM 70200-R

Liquid penetrant inspection of weld was found to be acceptable, for each plate.

QA-PT-

PENETRANT INSPECTOR T. Moore

Cable "Robin" New York

TODD SHIPYARDS CORPORATION

Seattle Division: 1801 16th Avenue, S.W. Seattle, Washington 98124 • 623-1635 (206)

REPORT NO. 7220

DATE 11-21-7

DIOGRAPHIC INSPECTION REPORT-WELDMENTS-- CONTRACT NO. NNS DOM 70200-R HULL N/A

NAME MARAD R & D PROJECT JOB NO. 4787 ITEM NO. 101.00 PAGE 1 OF

SCRIPTION PROCEDURE PLATES MAT'L ALUM QUANTITY 4

S NO. S-A-1 QUALITY LEVEL: 2-2T ☒ 2-4T ☐ --% RT: 100% ☒ 50% ☐ 10% ☐ SPOT ☐

MIL- STD-271-E ☒
NAVSHIPS 0900-003-9000,CLASS
ABS CLASS A ☐ CLASS B ☐
OTHER:

	SFD (INCHES)	THICKNESS (INCHES)	SEQUENCE NO.	VIEW	ORIG. or REP.	POROSITY	INCLUSIONS	INCOMPLETE PENETRATION	INCOMPLETE FUSION	CRACK	UNDERCUT	SURFACE	OTHER	DISPOSITION: JOINT	ACCEPT	REJECT	REMARKS
	30	.063	-	0-1	0		/				/	/		A1-34	X		
		.100	-	0-1	0	/	/				/	/		B-77	X		
		.125	-	0-1	0						/	/		C-65	X		
		.125	-	0-1	0	/					/	/		C-67	X		

CODE
ACCEPTABLE
BORDERLINE
EXCESSIVE

RADIATION SOURCE:
X-RAY: KV 100 mA 1.2
IR-192: CURIES NA

INGLE FILM ☒
ULTIFILM ☐
OTH ☐

NO. OF VIEWS	FILM SIZE AND QUANTITY			
	4½×17	4½×10		
4	4			

ADIOGRAPHER(S) T. MOORE

PREPARED BY R. BELL

APPROVED BY R. Bell

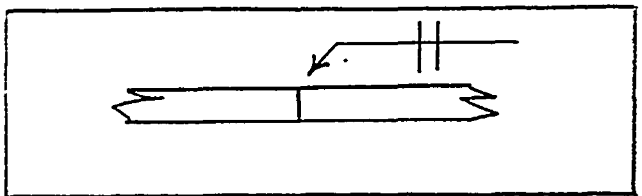
ACCEPTED BY

PACIFIC SHIPYARDS CORPORATION

SEATTLE DIVISION

WELDING PROCEDURE QUALIFICATION TEST SUMMARY

TEST SERIES NO. C.68, C.69, C.70
PROCEDURE NO.
PROCESS PULSE GMAW, MECHANIZED
CONTRACT MARAD SP-7
DATE 12/1/83



QUALIFICATION JOINT

MATERIALS:
BASE SPEC. 5083 H-323
QQ-A-250/6
MATL. THICKNESS .125"
FILLER SPEC. AWS A5.10-80
ER 5556
FILLER DIA. 3/64"
SHIELDING GAS 75%HE/25%AR
FLUX AND SIZE NA

EQUIPMENT:
POWER SUPPLY MILLER PULSTAR 450
TORCH OR HOLDER TYPE AH 35 C-2
CUP TYPE & SIZE 3/4" METALLIC
ELECTRODE TYPE & SIZE NA

OPERATING PARAMETERS:
WELDING POS. FLAT NO. PASSES 1
PREHEAT 60F MIN. INTERPASS TEMP. NA
CURRENT CHARAC. DCRP
CURRENT RANGE 70
VOLTAGE RANGE 21.2
WIRE FEED IPM 170
SHIELD FLOW 40 CFH
TRAVEL SPEED 16.1 IPM
MAX. HEAT INPUT J/IN NA
HEAT TREAT NA
OTHER "BUG-O" CARRIAGE WITH POST MOUNTED TORCH
60 pps

NDT TESTS:

[X] VIS. [X] PT [ ] UT [X] RT [ ] MT

DT TESTS: PLATE OR SPEC. SER. NO.

- [ ] RST
- [ ] HRDNS
- [ ] CHARPY
- [ ] SIDE BEND
- [ ] ROOT BEND
- [ ] FACE BEND
- [ ] FILLET BEND
- [ ] FILLET BREAK
- [ ] TRANS. SHEAR
- [ ] LONG SHEAR
- [ ] EXPL. BULGE
- [ ] OTHER

RESULTS:
Visual - No visible defects
P.T. Acceptable - Report # 1871 attached
R.T. Acceptable - Report # 7226 attached

REMARKS:

J.H. HITCH J H Hitch 10879 J.C. JOHNSTON
WELD OPR. CLOCK NO. TEST BY QUAL. RANGE

THIS CERTIFIES THAT THE DATA HEREIN IS COMPLETE AND ACCURATE TO BEST POSSIBLE KNOWLEDGE AND THAT TESTING AND EVALUATION WAS CONDUCTED IN ACCORDANCE WITH THE REQUIREMENTS LISTED BELOW.

James C Johnston
WELDING ENGINEER DATE

TODD SHIPYARDS CORPORATION
SEATTLE DIVISION
QUALITY ASSURANCE DEPARTMENT

DATE 11-28-83

TODD ORDER NO. 4787 ITEM NO. 101.00 REPORT NO. 1871

DYE PENETRANT NONDESTRUCTIVE TEST REPORT

JOB DESCRIPTION

MARAD PLATE GMAW PULSED ARC PROCESS

FOR: TWPS No. C.68, C.69, C.70	MATERIAL: Aluminum
PENETRANT EQUIP. DUBL-CHEK; VISIBLE RED	PENETRANT TIME: 15-20 min.
REPORTS TO: Distribution	DEVELOPMENT TIME: 7-30 min.
PER SPEC: MIL-STD-271 E , NAVSHIPS 0900-003-8000, CLASS I	

CONTRACT NO. NNS POM 70200-R

Liquid penetrant inspection of weld was found to be acceptable, for each of the welds inspected.

QA-PT-

PENETRANT INSPECTOR J. Posten

J. Posten

Cable "Robin" New York

TODD SHIPYARDS CORPORATION

Seattle Division: 1801 16th Avenue, S.W. Seattle, Washington 98124 • 623-1635 (206)

REPORT NO. 7226

DATE 11-23-83

RADIOGRAPHIC INSPECTION REPORT-WELDMENTS-- CONTRACT NO. NNS-POM-70200-R HULL N/A

JOB NAME MARAD PROCEDURE PLATES JOB NO. 4787 ITEM NO. 101.00 PAGE 1 of 1

DESCRIPTION C-68, C-69, C-70 MAT'L ALUM. QUANTITY 3

PROCESS NO. S-A-1 QUALITY LEVEL: 2-2T ☒ 2-4T ☐ --% RT: 100% ☒ 50% ☐ 10% ☐ SPOT ☐

MIL- STD-271-E ☒
NAVSHIPS 0900-003-9000, CLASS 1
ABS CLASS A ☐ CLASS B ☐
OTHER:

FILM TYPE(S)	SFD (INCHES)	THICKNESS (INCHES)	SEQUENCE NO.	VIEW	ORIG. or REP.	POROSITY	INCLUSIONS	INCOMPLETE PENETRATION	INCOMPLETE FUSION	CRACK	UNDERCUT	SURFACE	OTHER	DISPOSITION: JOINT	ACCEPT	REJECT	REMARKS
4	30	.125	-	0-1	O						1	1		C-68	X		
|	|	.125	-	0-1	O						1	1		C-69	X		
|	|	.125	-	0-1	O						1	1		C-70	X		

CODE
ACCEPTABLE
BORDERLINE
EXCESSIVE

SINGLE FILM ☒
MULTIFILM ☐
BOTH ☐

RADIATION SOURCE:
X-RAY: KV 100 mA 1.2
IR-192: CURIES NA

NO. OF VIEWS	FILM SIZE AND QUANTITY: 4½×17	4½×10		
3	3			

PREPARED BY R. Bell

APPROVED BY R. Bell

ACCEPTED BY

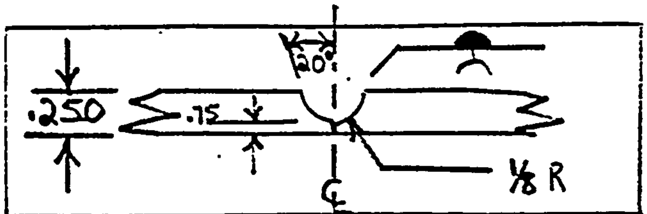
RADIOGRAPHER(S) Moore

PACIFIC SHIPYARDS CORPORATION

SEATTLE DIVISION

WELDING PROCEDURE QUALIFICATION TEST SUMMARY

TEST SERIES NO. D-25
PROCEDURE NO.
PROCESS GMAW MECHANIZED PULSE
CONTRACT MARAD SP-7
DATE 12/1/83



QUALIFICATION JOINT

MATERIALS:
BASE SPEC. QQ-A-250/19
5086 H-116
MATL. THICKNESS .250"
FILLER SPEC. ER 5556
AWS A5.10-80
FILLER DIA. 3/64"
SHIELDING GAS 100% Helium
FLUX AND SIZE NA
EQUIPMENT:
POWER SUPPLY MILLER PULSTAR 450
TORCH OR HOLDER TYPE AIRCO AH NP 35
CUP TYPE & SIZE METALLIC 3/4"
ELECTRODE TYPE & SIZE NA

OPERATING PARAMETERS:
WELDING POS. FLAT NO. PASSES 2
PREHEAT 60F MIN. INTERPASS TEMP. 300 F MAX.
CURRENT CHARAC. DCRP
CURRENT RANGE 105 105

VOLTAGE RANGE 23 24

WIRE FEED IPM 355 380

SHIELD FLOW 40 CFH
TRAVEL SPEED 16 IPM 12.2 IPM

MAX. HEAT INPUT J/IN NA
HEAT TREAT NA

OTHER "BUGO" CARRIAGE WITH POST MOUNTED TORCH
120 PPS

NDT TESTS:

[X] VIS. [X] PT [ ] UT [X] RT [ ] MT

DT TESTS: PLATE OR SPEC. SER. NO.

[ ] RST
[ ] HRDNS
[ ] CHARPY
[ ] SIDE BEND
[ ] ROOT BEND
[ ] FACE BEND
[ ] FILLET BEND
[ ] FILLET BREAK
[ ] TRANS. SHEAR
[ ] LONG SHEAR
[ ] EXPL. BULGE
[ ] OTHER

RESULTS:
Visual - No visible defects

P.T. Acceptable - Report # 1850 attached

R.T. Acceptable - Report # 7182 attached

REMARKS:

J. HITCH (signature) I0879 J.C. JOHNSTON
WELD OPR. CLOCK NO. TEST BY QUAL. RANGE

THIS CERTIFIES THAT THE DATA HEREIN IS COMPLETE AND ACCURATE TO BEST POSSIBLE KNOWLEDGE AND THAT TESTING AND EVALUATION WAS CONDUCTED IN ACCORDANCE WITH THE REQUIREMENTS LISTED BELOW.

(signature)

TODD SHIPYARDS CORPORATION
SEATTLE DIVISION
QUALITY ASSURANCE DEPARTMENT

DATE 10-24-83

TODD ORDER NO. 4787 ITEM NO. 101.00 REPORT NO. 1850

DYE PENETRANT NONDESTRUCTIVE TEST REPORT

JOB DESCRIPTION	
MARAD PLATE GMAW PULSE PROCESS	
FOR: TWPS No. D-25	MATERIAL: Aluminum
PENETRANT EQUIP. DUBL-CHEK; VISIBLE RED	PENETRANT TIME: 15-20 min.
REPORTS TO: Distribution	DEVELOPMENT TIME: 7-30 min.
PER SPEC: MIL-STD-271 E , NAVSHIPS 0900-003-8000, CLASS I	

CONTRACT NO. NNS POM 70200-R

Liquid penetrant inspection of weld was found to be acceptable.

G. Miller
J. Posten
PENETRANT INSPECTOR R. Bell

QA-PT-

Cable "Robin" New York

TODD SHIPYARDS CORPORATION

Seattle Division: 1801 16th Avenue, S.W. Seattle, Washington 98124 • 623-1635 (206)

REPORT NO. 7182
DATE 10-24-83

ADIOGRAPHIC INSPECTION REPORT-WELDMENTS-- CONTRACT NO. NNS POM-70200-R HULL N/A

IB NAME TWPS No. D-25 JOB NO. 4787 ITEM NO. 101.00 PAGE 1 of 1

ESCRIPTION MARAD PLATE GMAW PULSE PROCESS MAT'L ALUM. .25" QUANTITY 1

SS NO. WQ-001-A QUALITY LEVEL: 2-2T [X] 2-4T [ ] --% RT: 100% [X] 50% [ ] 10% [ ] SPOT [ ]

MIL- STD-271-E [X]
NAVSHIPS 0900-003-9000, CLASS 1
ABS CLASS A [ ] CLASS B [ ]
OTHER:

FILM TYPE(S)	SFD (INCHES)	THICKNESS (INCHES)	SEQUENCE NO.	VIEW	ORIG. or REP.	POROSITY	INCLUSIONS	INCOMPLETE PENETRATION	INCOMPLETE FUSION	CRACK	UNDERCUT	SURFACE	OTHER	DISPOSITION JOINT	ACCEPT	REJECT	REMARKS
-4	30	.25	-	0-1	0	1	1				1	1		D-25	X		

CODE
ACCEPTABLE
BORDERLINE
EXCESSIVE

RADIATION SOURCE:
X-RAY: KV 80 mA 2
IR-192: CURIES N/A

:GLE FILM [X]
MULTIFILM [ ]
BOTH [ ]

NO. OF VIEWS	FILM SIZE AND QUANTITY			
	4½×17	4½×10		
1	2			

RADIOGRAPHER(S) T. Moore

PREPARED BY T. Moore

APPROVED BY R. Bell TODD SEA 1

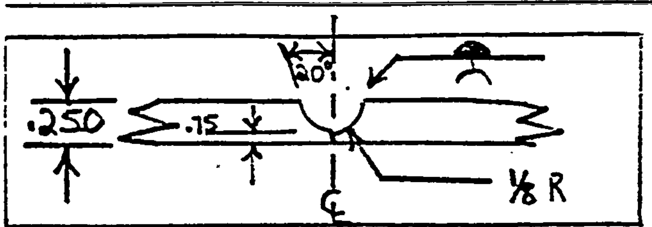
ACCEPTED BY

PACIFIC SHIPYARDS CORPORATION

SEATTLE DIVISION

WELDING PROCEDURE QUALIFICATION TEST SUMMARY

TEST SERIES NO. D-28
PROCEDURE NO.
PROCESS MECHANIZED PULSE GMAW
CONTRACT MARAD- SP-7
DATE 12/1/83



QUALIFICATION JOINT

MATERIALS:
BASE SPEC. QQ-A-250/19
5086 H-116
MATL. THICKNESS .250"
FILLER SPEC. AWS A5.10-80
ER 5356
FILLER DIA. 3/64"
SHIELDING GAS 75% HE/25% AR
FLUX AND SIZE NA

EQUIPMENT:
POWER SUPPLY AIRCO PA 350
TORCH OR HOLDER TYPE BINZEL
CUP TYPE & SIZE 3/4" METALLIC
ELECTRODE TYPE & SIZE NA

OPERATING PARAMETERS:
WELDING POS. FLAT NO. PASSES 2
PREHEAT 60F MIN. INTERPASS TEMP. 300F MAX.
CURRENT CHARAC. DCRP
CURRENT RANGE 92 124
VOLTAGE RANGE 24.8 26.5
WIRE FEED IPM 234 314
SHIELD FLOW 40 CFH
TRAVEL SPEED 12.2 16 IPM
MAX. HEAT INPUT J/IN NA
HEAT TREAT NA
OTHER "BUG-O" CARRIAGE WITH POST MOUNTED TORCH, ELECTRONICALLY PROGRAMMED WIRE FEED

NDT TESTS:
[X] VIS. [X] PT [ ] UT [X] RT [ ] MT

DT TESTS: PLATE OR SPEC. SER. NO.
[ ] RST
[ ] HRDNS
[ ] CHARPY
[ ] SIDE BEND
[ ] ROOT BEND
[ ] FACE BEND
[ ] FILLET BEND
[ ] FILLET BREAK
[ ] TRANS.SHEAR
[ ] LONG SHEAR
[ ] EXPL.BULGE
[ ] OTHER

RESULTS:
Visual - No visible defects
P.T. Acceptable - Report # 1851 attached
R.T. Acceptable - Report # 7181 attached

REMARKS:

J. HITCH	10879	J.C. JOHNSTON	
WELD OPR.	CLOCK NO.	TEST BY	QUAL. RANGE

THIS CERTIFIES THAT THE DATA HEREIN IS COMPLETE AND ACCURATE TO BEST POSSIBLE KNOWLEDGE AND THAT TESTING AND EVALUATION WAS CONDUCTED IN ACCORDANCE WITH THE REQUIREMENTS LISTED BELOW.

TODD SHIPYARDS CORPORATION
SEATTLE DIVISION
QUALITY ASSURANCE DEPARTMENT

DATE 10-24-83

TODD ORDER NO. 4787 ITEM NO. 101.00 REPORT NO. 1851

DYE PENETRANT NONDESTRUCTIVE TEST REPORT

JOB DESCRIPTION

MARAD PLATE GMAW PULSE PROCESS

FOR: TWPS No. D-28	MATERIAL: Aluminum
PENETRANT EQUIP. DUBL-CHEK; VISIBLE RED	PENETRANT TIME: 15-20 min.
REPORTS TO: Distribution	DEVELOPMENT TIME: 7-30 min.

PER SPEC: MIL-STD-271 E, NAVSHIPS 0900-003-8000, CLASS I

CONTRACT NO. NNS POM 70200-R

Liquid penetrant inspection of weld was found to be acceptable.

G. Miller
J. Posten
PENETRANT INSPECTOR R. Bell

QA-PT-

Cable "Robin" New York

TODD SHIPYARDS CORPORATION

Seattle Division: 1801 16th Avenue, S.W. Seattle, Washington 98124 • 623-1635 (206)

REPORT NO. 7181
DATE 10-24-83

ADIOGRAPHIC INSPECTION REPORT-WELDMENTS-- CONTRACT NO. NNS POM 70200-R HULL N/A

IB NAME TWPS - D-28 JOB NO. 4787 ITEM NO. 101.00 PAGE 1 of 1

ESCRIPTION MARAD PLATE GMAW PULSE PROCESS MAT'L ALUM. .25" QUANTITY 1

SS NO. WQ-001-A QUALITY LEVEL: 2-2T [X] 2-4T [ ] --% RT: 100% [X] 50% [ ] 10% [ ] SPOT [ ]

MIL- STD-271-E [X]
NAVSHIPS 0900-003-9000, CLASS 1
ABS CLASS A [ ] CLASS B [ ]
OTHER:

FILM TYPE(S)	SFD (INCHES)	THICKNESS (INCHES)	SEQUENCE NO.	VIEW	ORIG. or REP.	POROSITY	INCLUSIONS	INCOMPLETE PENETRATION	INCOMPLETE FUSION	CRACK	UNDERCUT	SURFACE	OTHER	DISPOSITION JOINT	ACCEPT	REJECT	REMARKS
-4	30	.25	-	0-1	0	1	1				1	1		D-28	X		

CODE
ACCEPTABLE
BORDERLINE
EXCESSIVE

RADIATION SOURCE:
X-RAY: KV 80 mA 2
IR-192: CURIES N/A

PREPARED BY T. Moore

APPROVED BY R. Bell TODD SEA 1

ACCEPTED BY

:GLE FILM [X]
MULTIFILM [ ]
BOTH [ ]

NO. OF VIEWS	FILM SIZE AND QUANTITY			
	4½×17	4½×10		
1	2			

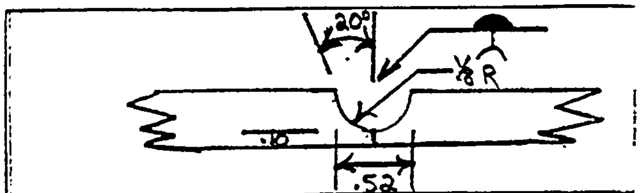
RADIOGRAPHER(S) T. Moore

TODD PACIFIC SHIPYARDS CORPORATION

SEATTLE DIVISION

WELDING PROCEDURE QUALIFICATION TEST SUMMARY

TEST SERIES NO. I-10
PROCEDURE NO.
PROCESS MECHANIZED PULSE GMAW
CONTRACT MARAD SP-7
DATE 12/1/83



QUALIFICATION JOINT

MATERIALS:
BASE SPEC. QQ-A-250/6
5083-H321
MATL. THICKNESS 1/2 INCH
FILLER SPEC. AWS A5.10-80
ER 5356
FILLER DIA. 3/64 INCH
SHIELDING GAS 75% HE/25% AR
FLUX AND SIZE NA
EQUIPMENT:
POWER SUPPLY MILLER PULSTAR 450
TORCH OR HOLDER TYPE AH 35 C-2
CUP TYPE & SIZE 3/4" METALLIC ORIFICE
ELECTRODE TYPE & SIZE NA

OPERATING PARAMETERS:
WELDING POS. FLAT NO. PASSES 3
PREHEAT 60F MIN. INTERPASS TEMP. 300F MAX.
CURRENT CHARAC. DCRP
CURRENT RANGE 150 160 157
VOLTAGE RANGE 25 28 28
WIRE FEED IPM 375 400 390
SHIELD FLOW 40 CFH
TRAVEL SPEED 14 11.5 11.5 IPM
MAX. HEAT INPUT J/IN NA
HEAT TREAT NA
OTHER "BUG-O" CARRIAGE WITH POST MOUNTED TORCH.
120 pps

NDT TESTS:

[x] VIS. [x] PT [ ] UT [x] RT [ ] MT

DT TESTS:	PLATE OR SPEC. SER. NO.
[x] RST	Sat. Report # E29361
[ ] HRDNS	
[ ] CHARPY	
[ ] SIDE BEND	
[x] ROOT BEND	Sat. Report # E29361
[x] FACE BEND	Sat. Report # E29361
[ ] FILLET BEND	
[ ] FILLET BREAK	
[ ] TRANS. SHEAR	
[ ] LONG SHEAR	
[ ] EXPL. BULGE	
[ ] OTHER	

RESULTS:
Visual - No visible defects

P.T. Acceptable - Report # 1848 attached

R.T. Acceptable - Report # 7173 attached

REMARKS:

J.H. HITCH [signature] 16879 J.C. JOHNSTON
WELD OPR. CLOCK NO. TEST BY QUAL. RANGE

THIS CERTIFIES THAT THE DATA HEREIN IS COMPLETE AND ACCURATE TO BEST POSSIBLE KNOWLEDGE AND THAT TESTING AND EVALUATION WAS CONDUCTED IN ACCORDANCE WITH THE REQUIREMENTS LISTED BELOW.

James C Johnston

TODD SHIPYARDS CORPORATION
SEATTLE DIVISION
QUALITY ASSURANCE DEPARTMENT

DATE October 19, 1983

TODD ORDER NO. 4787 ITEM NO. 101.00 REPORT NO. 1848

DYE PENETRANT NONDESTRUCTIVE TEST REPORT

JOB DESCRIPTION

MARAD PLATE GMAW PULSE PROCESS

FOR: TWPS No. I-10 - Flat	MATERIAL: Aluminum
PENETRANT EQUIP. DUBL-CHEK; VISIBLE RED	PENETRANT TIME: 15-20 min.
REPORTS TO: Distribution	DEVELOPMENT TIME: 7-30 min.

PER SPEC: MIL-STD-271 E , NAVSHIPS 0900-003-8000, CLASS I

CONTRACT NO. NNS POM 70200-R

Liquid penetrant inspection of weld was found to be acceptable.

PENETRANT INSPECTOR G. Miller R. Bell

QA-PT-

Cable "Robin" New York

TODD SHIPYARDS CORPORATION

Seattle Division: 1801 16th Avenue, S.W. Seattle, Washington 98124 • 623-1635 (206)

REPORT NO. 7173
DATE 10-19-83

ADIOGRAPHIC INSPECTION REPORT-WELDMENTS-- CONTRACT NO. NNS-POM-70200-R HULL N/A

B NAME TWPS No. I-10 5083 H 321 JOB NO. 4787 ITEM NO. 101.00 PAGE 1 of 1

ESCRIPTION MARAD PLATE GMAW PULSE PROCESS MAT'L ALUM. 1/2" QUANTITY 1

SS NO. WQ-001-A QUALITY LEVEL: 2-2T [X] 2-4T [ ] --% RT: 100% [X] 50% [ ] 10% [ ] SPOT [ ]

MIL- STD-271-E [X]
NAVSHIPS 0900-003-9000, CLASS 1
ABS CLASS A [ ] CLASS B [ ]
OTHER:

FILM TYPE(S)	SFD (INCHES)	THICKNESS (INCHES)	SEQUENCE NO.	VIEW	ORIG. or REP.	POROSITY	INCLUSIONS	INCOMPLETE PENETRATION	INCOMPLETE FUSION	CRACK	UNDERCUT	SURFACE	OTHER	DISPOSITION JOINT	ACCEPT	REJECT	REMARKS
-4	30	.50	-	0-1	0	1					1	1		FLAT	X		

CODE
ACCEPTABLE
BORDERLINE
EXCESSIVE

RADIATION SOURCE:
X-RAY: KV 100 mA 3
IR-192: CURIES N/A

SINGLE FILM [X]
MULTIFILM [ ]
BOTH [ ]

NO. OF VIEWS	FILM SIZE AND QUANTITY 4½×17	4½×10		
1	1			

PREPARED BY R. Bell
APPROVED BY R. Bell
ACCEPTED BY

TODD SEA 1

RADIOGRAPHER(S) T. Moore/G. Miller

RA-RT-2

CHIPPING

The chipping gun is still the preferred tool for removing excessive weld penetration reinforcement on the second side. The method still offers the fastest cuts and best grooves for removing weld defects and preparing for repair welding.

Excessive reinforcements on the torch side (first side) and the back side (second side) maybe removed with the use of a flat configuration chisel and should be worked to the high side of the weld butt joint so that the base material thickness will not be reduced. ln general, the other half of the weld joint will fair in smoothly by itself.

Flat “V” and spoon shape chisels were made per sample from 401 Parker taper shanks. All chisels were approximately 6 inches long x 13/32 inches diameter shank blanks. Figures 61 and 62 illustrate the flat “V” and spoon configurations of chisels used.

Figure 63 is a photograph of the three chisel configurations.

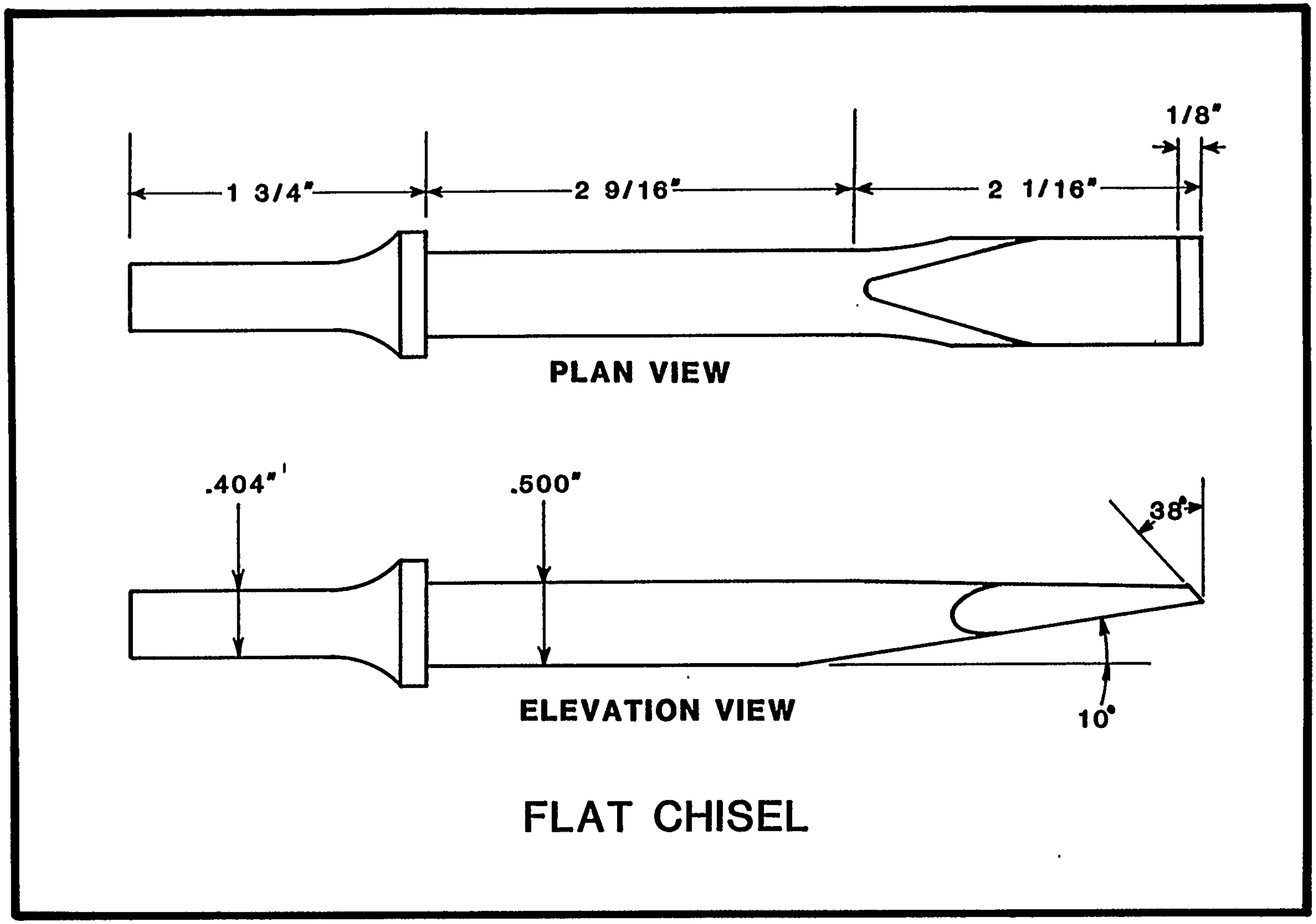


FIGURE 61
FLAT CHISEL CONFIGURATION

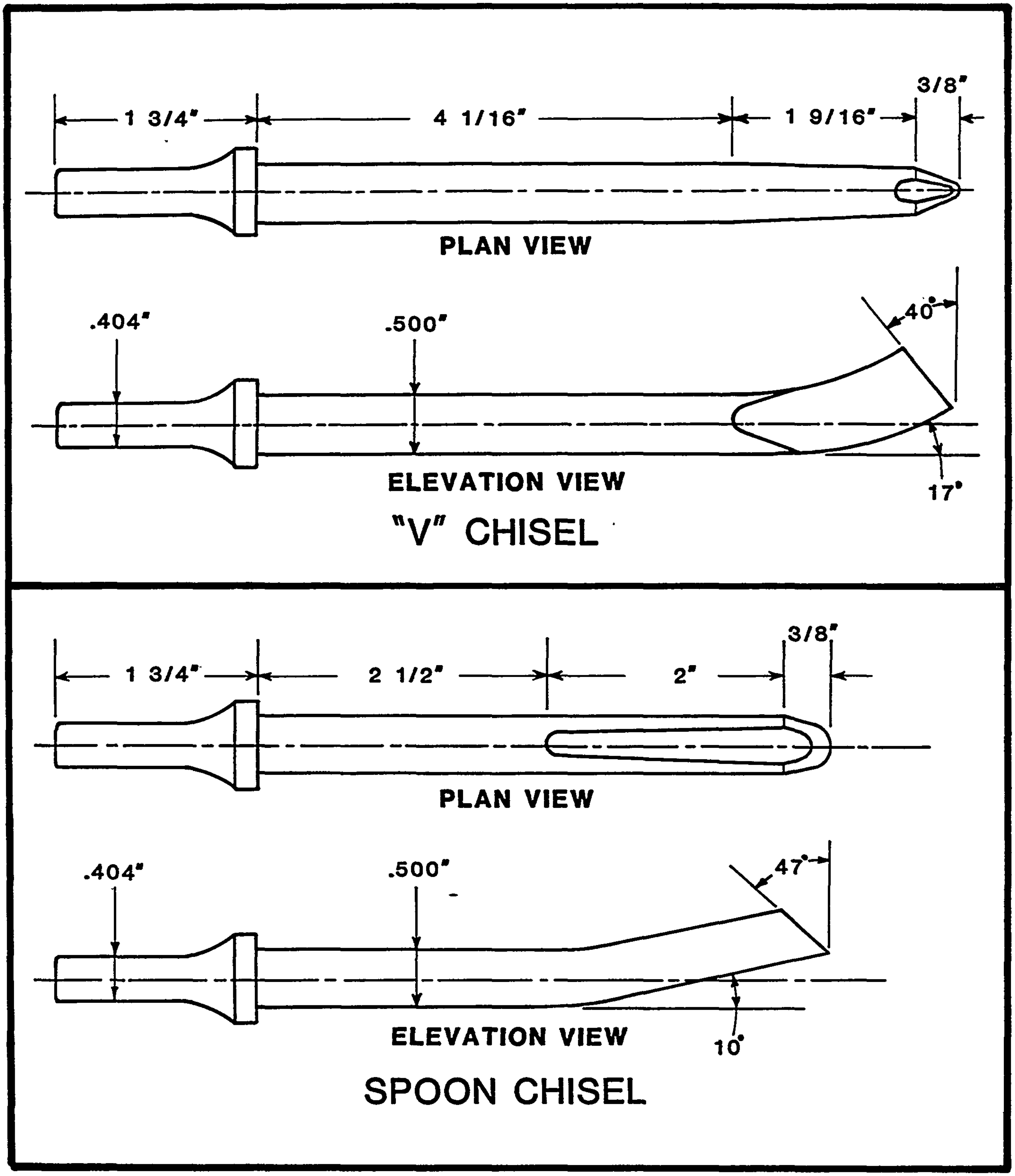


FIGURE 62
CHISEL CONFIGURATIONS

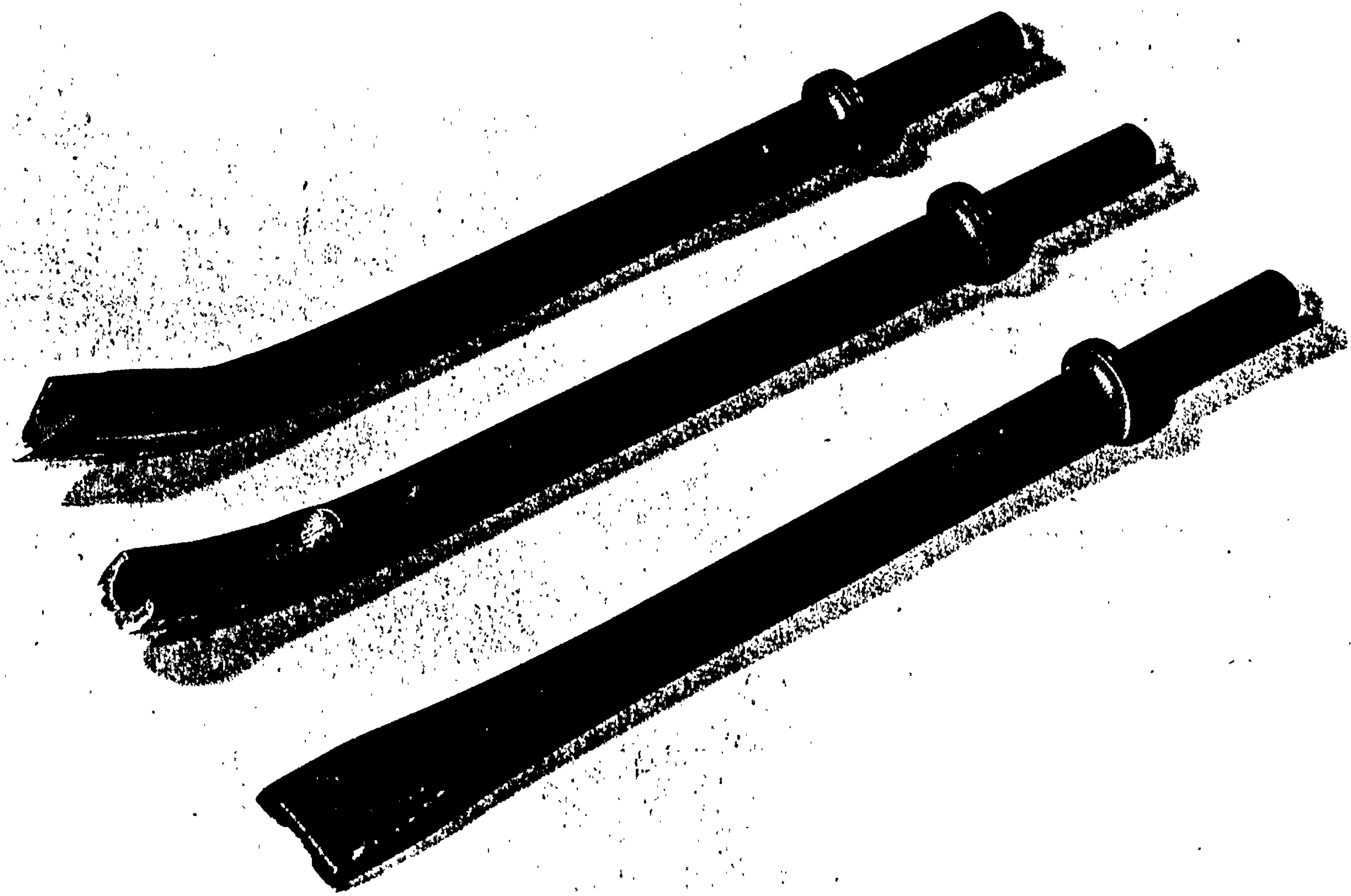


FIGURE 63
"V". "U" AND FLAT CHISELS

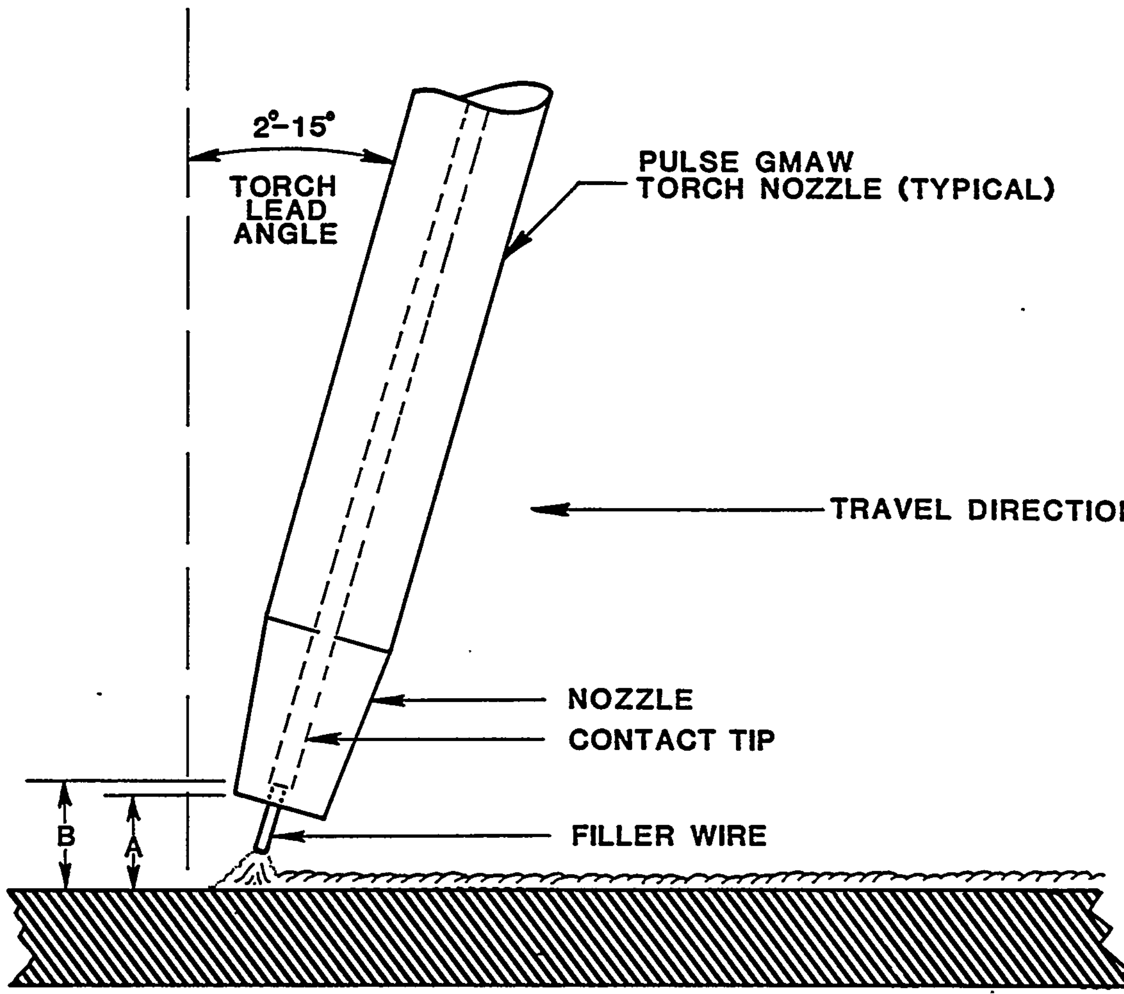
WELDING TECHNIQUE

In general, the preferred welding technique was to run stringer bead welds in the root passes when using either the pulse spray or the "pulse short-circuiting mode". Single pass stringer bead welds were made in material thicknesses up to 1/4 inch. However, because of longer periods at temperatures involved, single pass welds should be limited to 1/8 inch maximum thickness.

When certified weld machine settings are established for sheet material under .125 inch thickness and when spatter and heat are minimized in the "pulse short-circuiting mode", it is feasible to weld all positions without the use of heavy leather gloves generally used for shielded metal arc welding.

It should be pointed out that the intent of the above statement relative to the feasibility of using bare hands pertains only to illustrate a welding condition of no spatter and should not be interpreted as justification towards violation of existing and established AWS and shipyard safety requirements to wear gloves for any type of welding.

Torch position and angles relative to the work piece and direction of travel were very similar to conventional gas metal arc welding. It appeared that torch positions and angles were less critical for the pulsed GMAW mode. See Figure 64 for sketch illustrating torch position and torch angle tolerances.



NOTE: A CUP-TO-WORK DISTANCE 3/8"- 3/4"
B CONTACT TIP-TO-WORK DISTANCE 1/2"- 3/4"

FIGURE 64

MANUAL PULSE GMAW
TORCH POSITION; TORCH ANGLES; CUP/CONTACT TIP TO-WORK DISTANCES

REPAIR WELDING

Only one repair with gas metal arc welding is allowed per MIL-STD-248 on all procedure qualification test panels. All repairs should be made in the same manner as the original weld, i.e. implementing the same welding power sources and accessories, welding position and original standard. Although no repairs were required on the test panels submitted for visual and radiographic inspection, it appears that standard repair techniques could be applied very readily.

When full penetration welds are deposited from one side, lack of fusion type defects are uncommon. On the other hand, incomplete fusion and lack of fusion are rather common when aluminum plate/sheet is welded from two sides, i.e. when the root weld beadc(s) from the first side do not interpenetrate with the root beads from the second side, lack of fusion on the joint side walls are common defects.

Incomplete weld penetration is usually caused because the welding current is too low or welding travel speed is too fast.

Incomplete weld penetration is a significantly disastrous defect. Full penetration welds on the side opposite the gas metal arc torch may be visually inspected readily for incomplete penetration.

PREHEAT , INTERPASS , AND POST-HEAT TEMPERATURES

In general, no preheat is required except to remove moisture. A gentle soot free oxy-gas torch flame or strip heaters may be used to provide uniform temperature not exceeding 300F for tempered condition of 5000 series aluminum alloys for marine fabrication. Preheat temperatures may be measured with a surface pyrometer or other suitable temperature indicating devices.

Interpass temperatures should be kept as low as feasible.

Since 5000 series aluminum alloys are not heat treatable, no post-heat requirement is necessary.

MECHANICAL PROPERTIES FOR 5000 SERIES ALUMINUM ALLOY SHEET AND PLATE BUTT WELDS (AS-WELDED CONTITION)

Weld mechanical properties were developed as basic weld procedure specification qualification back-up data per the requirements of MIL-STD-248, "Welding Procedure and Performance Qualifications." Through the use of standard Navy procedures for the development and establishment of welding procedure qualification tests, typical as-welded condition mechanical properties were readily attained. All butt weld test specimens were 5000 series aluminum alloy sheet and plate material manually welded out-of-position, one-side, full penetration type with the use of the pulse gas metal arc process.

Although the welding tests were conducted in the welding laboratory, all test specimens were welded under conditions as close as possible to actual production fabrication. This practical approach was encompassed because welding variables greatly reflect mechariical properties values for 5000 series aluminum alloys, and naval architects and marine engineers are primarily concerned with as-welded mechanical properties.

The non-heat treatable 5000 series aluminum alloys depend upon chemical composition and cold working or strain hardening for their mechanical properties. Welding primarily affects these alloys by annealing. When welding heat input is increased, the width of the heat-affected-zone(HAZ) is increased. Significant changes in-weld metal strength occur as heat input varies by welding techniques. It has been reported that yield strength (Psi) could vary from 35,000 psi for stringer type weld beads to 30,000 psi for tide weave type weld deposits. The mechanical properties of a weld decrease with increased total heat input.

Upon completion of welding and non-destructive testing, as described earlier in this report, the weld procedure qualification test panels (approximately 12". x 16" x T), were sawed into tensile and bend specimens. See Figure 65 which illustrates the cutting diagram of the test panel. Tensile specimens (transverse welds) and root and face bend specimens were machined per sketches in Figures 66 and 67.

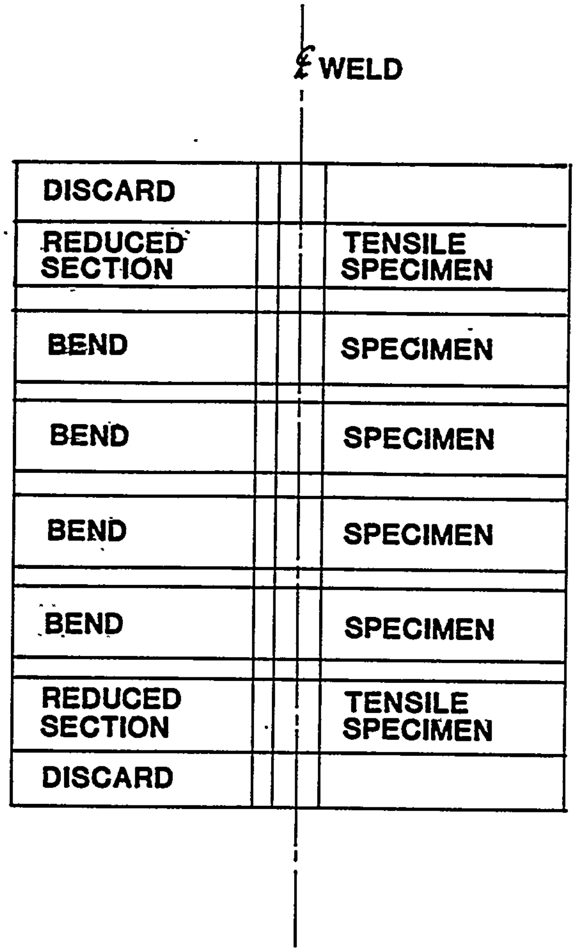


FIGURE 65

CUTTING DIAGRAM OF WELD TEST PANELS
FOR TENSILE & BEND TEST SPECIMENS

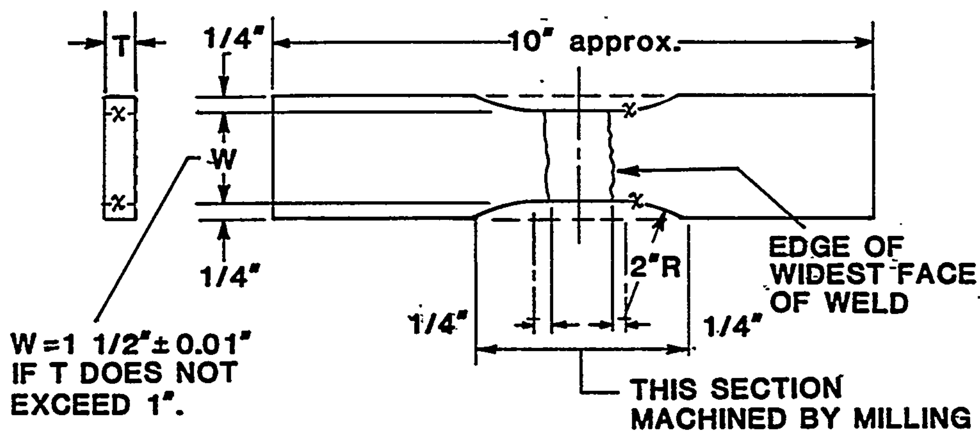
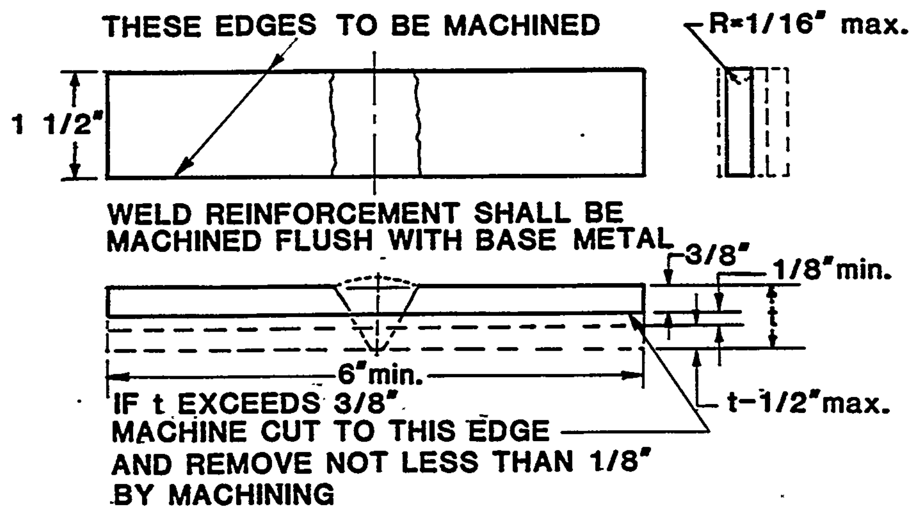
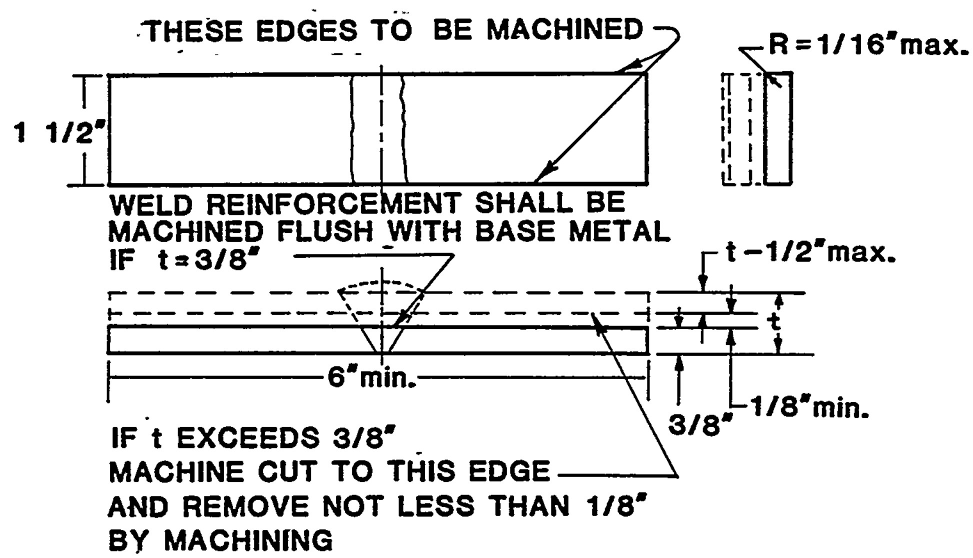


FIGURE 66

TRANSVERSE WELD TENSILE SPECIMEN CONFIGURATION



FACE BEND SPECIMEN



ROOT BEND SPECIMEN

FIGURE 67

TRANSVERSE FACE AND ROOT BEND SPECIMEN CONFIGURATIONS

All surface and underbead weld reinforcements were removed flush by machining. A typical set of flush-machined, transverse weld, reduced section tensile specimens and root and face bend specimens are shown in Figure 68.

For convenience, the general welding parameters for mechanical property test panels are listed according to their code identification numbers. See Figure 69. For specific detailed information, see the following section covering Machine Settings. Also, 5000 series aluminum alloy "0" temper tensile and yield strengths are specified in Figure 70.

*   *   *   *   *   *   *

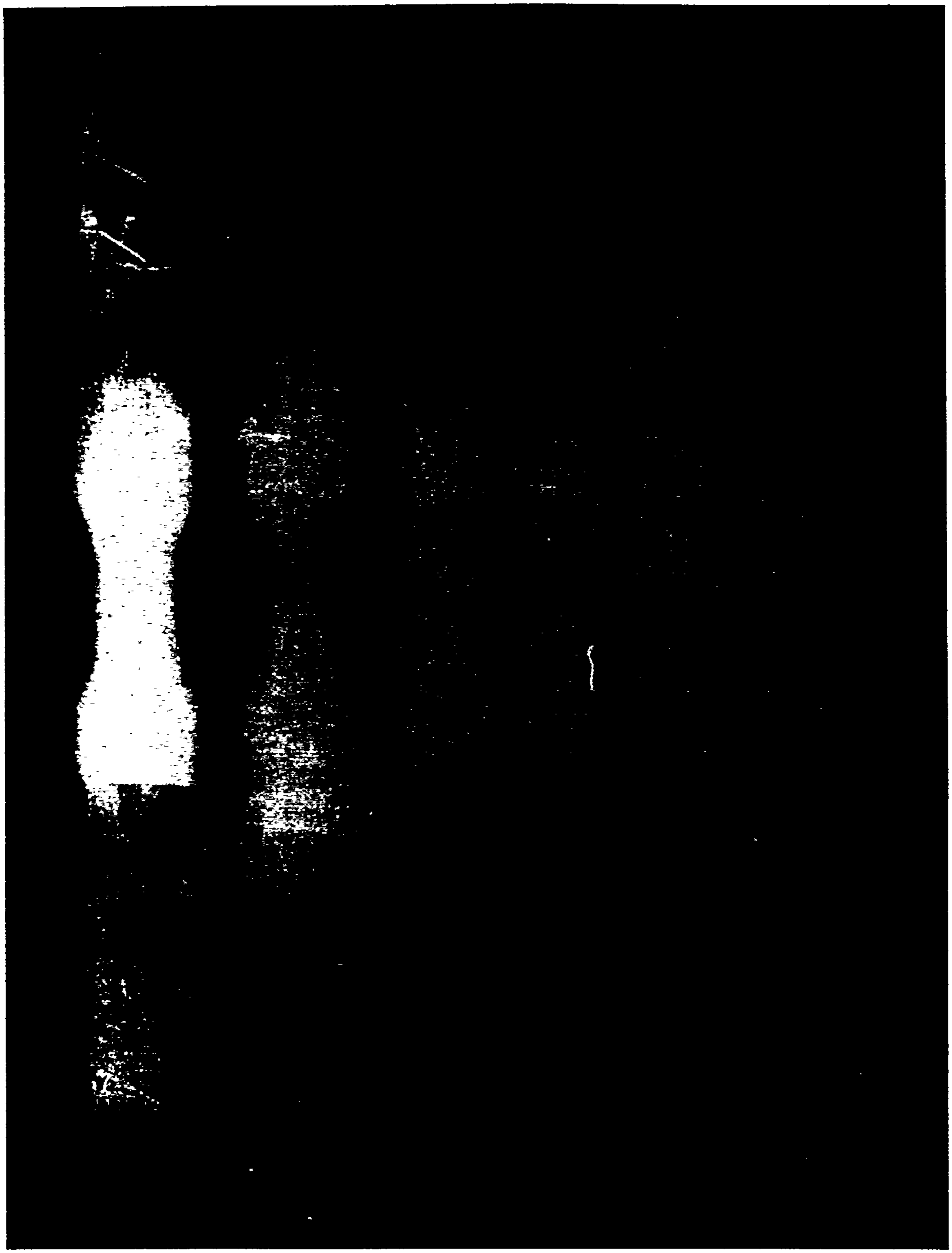


FIGURE 68
TYPICAL FLUSH MACHINED, TRANSVERSE WELD,
REDUCED SECTION TENSILE & ROOT & FACE BEND SPECIMENS
(0.100" THICK 5086 H-32; VERTICAL-UP; 5356 FILLER)

MATERIAL THICKNESS	PLATE NO.	VOLT	AMP.	WIRE SPEED	TRAVEL SPEED	POWER SOURCE	WIRE DIA.	FILLER ALLOY
.063"	A1.3	15	50	125	18	PA-350	3/64"	5556
.063"	A1.23	15.5	40	172	18.5	PA-350	3/64"	5356
.063"	A1.14	15	50	168	18	PA-350	3/64"	5556
.063"	A2.5	15.5	50	155	20	PA-350	3/64"	5556
.100"	B.18	19	45	300	15.6	PA-3A	.030"	5356
.100"	B.50	19	55	260	18	PA-3A	.035"	5356
.100"	B.74	16	70	205	17	PA-350	3/64"	5356
.125"	C.60	17	70	225	12.8	PA-350	3/64"	5356
.125"	C.63	17	70	240	14.1	PA-350	3/64"	5556
.125"	C.30	19.5	85	245	15	PA-350	3/64"	5556
.125"	C.46	15	105	280	20	PA-350	3/64"	5356
.250"	D.8	16	150	362	11.5	PA-350	3/64"	5556
.250" 1	D.10	14.5	149	327	8.4	PA-350	3/64"	5556
.250" 1	E.33	14.5	156	343	8.9	PA-350	3/64"	5556
.250"	F.3	15.7	130	330	12	PA-350	3/64"	5556
.250" 1	F.13	14.5	145	333	10.2	PA-350	3/64"	5556
.500"	I.10	25	150	375	14	PULSTAR 450	3/64"	5356
		28	160	400	11.5			
		28	157	390	11.5			

FIGURE 69
WELDING PARAMETERS FOR MECHANICAL PROPERTIES TESTS PANELS

ALUMINUM ALLOY	SHEET/PLATE THICKNESS	MATERIAL SPECIFICATION	"O" TEMPER MECHANICAL PROPERTIES				
			TENSILE STRENGTH psi		YIELD STRENGTH		ELONGATION (IN 2 INCHES)
			MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	
5086 H-32	.063"; .10"	QQ-A-250/7	35,000	44,000	14,000		18
5086 H-116	1/4"; 1/2"	QQ-A-250/19	35,000	44,000	14,000	---------	16
5083 H-323	1/8"	QQ-A-250/6	40,000	51,000	18,000	29,000	16
5083 H-321	1/4"						
5083 H-321	1/2"						
5456 H-116	1/4"; 1/2"	QQ-A-250/20	42,000	53,000	19,000		16

FIGURE 70

5000 SERIES ALUMINUM ALLOY
"O" TEMPER MECHANICAL PROPERTIES

NORTHWEST LABORATORIES' REPORTS

All testing of weld mechanical properties specimens were conducted at Northwest Laboratories in Seattle, Washington, an independent testing laboratory. AIS of the aluminum alloy test specimens were tested on a Tinius Olson Super “L” Universal Testing Machine calibrated one step removed from the National Bureau of Standards. This machine was calibrated on April 8, 1983 by Pacific Scientific Company.

The following pages cover specific and pertinmt detailed Northwest Laboratories' reports covering out-of-position, one-side, full penetration manual pulse gas metal arc butt welding of 5000 series aluminum alloy sheet and plate. A summary of the mechanical properties data, and photographs of the mechanical properties specimens after destructive testing are shown in Figures 71, 72, and 73.

NORTHWEST LABORATORIES

of Seattle, Incorporated

ESTABLISHED 1896

Technical Services for: Industry, Commerce, Legal Profession & Insurance Industry

1530 FIRST AVENUE SOUTH • SEATTLE, WASHINGTON 98134 • Telephone: (206) 622-0680

Report To: Todd Pacific Shipyards Corp. Date: June 17, 1983

Report On: Aluminum Welds, PO PS81431 Lab No: E 28426-2

IDENTIFICATION:

Test No. Al.3 Vertical Up
Base Material & Temper 5086-H32 QQ-A-250/7
Material Thickness - 0.063"
Filler Metal- 5556
Test Procedure - Mil-Std-248C

TEST RESULTS:

Bar Number	T1	T2	Specified
Measurements	0.055 x 1.506	0.057 x 1.507	
Area Sq. Inches	0.0828	0.0859	
Yield Strength, Lbs. Actual	1,960	1,980	
Yield Strength, PSI	23,670	23,050	Info only
Ultimate Load, Lbs.	2,980	3,080	
Tensile Strength, PSI	35,990	35,860	35,000 min.
Elongation in 2 inches	0.14	0.17	
Elongation, %	7.0	8.5	Info only
Fracture Location	HAZ	HAZ	---

BEND TESTS

Number	Type of Bend	Results
1	Face	No defects, Satisfactory
2	Face	No defects, Satisfactory
3	Root	No defects, Satisfactory
4	Root	No defects, Satisfactory

NORTHWEST LABORATORIES

ALBERT O. WAHTO, PE
Chief Testing Engineer
License No. 3004

NORTHWEST LABORATORIES

of Seattle, Incorporated

ESTABLISHED 1896

Technical Services for: Industry, Commerce, Legal Profession & Insurance Industry

1530 FIRST AVENUE SOUTH • SEATTLE, WASHINGTON 98134 • Telephone: (206) 622-0680

Report To: Todd Pacific Shipyards Corp. Date: June 17, 1983

Report On: Aluminum Welds, PO PS81431 Lab No: E 28426-3

IDENTIFICATION:

Test No. A1.23 Vertical Up
Base Material & Temper 5086-H32 QQ-A-250/7
Material Thickness - 0.063"
Filler Metal- 5356
Test Procedure - Mil-Std-248C

TEST RESULTS:

Bar Number	T1	T2	Specified
Measurements	0.053 x 1.510	0.051 x 1.510	
Area Sq. Inches	0.0800	0.0770	
Yield Strength, Lbs. Actual	1,820	1,800	
Yield Strength, PSI	22,750	23,380	Info only
Ultimate Load, Lbs.	2,940	2,880	
Tensile Strength, PSI	36,750	37,400	35,000 min.
Elongation in 2 inches	0.18	0.17	
Elongation, %	9.0	8.5	Info only
Fracture Location	Thru weld	Thru weld	---

BEND TESTS

Number	Type of Bend	Results
1	Face	No defects, Satisfactory
2	Face	No defects, Satisfactory
3	Root	No defects, Satisfactory
4	Root	No defects, Satisfactory

NORTHWEST LABORATORIES

ALBERT O. WAHTO. PE

NORTHWEST LABORATORIES
of Seattle, Incorporated
ESTABLISHED 1896

Technical Services for: Industry, Commerce, Legal Profession & Insurance Industry

1530 FIRST AVENUE SOUTH • SEATTLE, WASHINGTON 98134 Telephone: (206) 622-0680

Report To: Todd Pacific Shipyards Corp. Date: June 17, 1983

Report On: Aluminum Welds, PO PS81431 Lab No: E 28426-1

IDENTIFICATION:

Test No. Al.14 Horizontal
Base Material & Temper 5086-H32 QQ-A-250/7
material Thickness - 0.063"
Filler Metal- 5556
Test Procedure - Mil-Std-248C

TEST RESULTS:

Bar Number	T1	T2	Specified
Measurements	0.048 X 1.508	0.052 X 1.507	
Area Sq. Inches	0.0724	0.0784	
Yield Strength, Lbs. Actual	1,810	1,800	
Yield Strength, PSI	25,000	22,960	Info only
Ultimate Load, Lbs.	2,680	2,760	
Tensile Strength, PSI	37,020	35,200	35,000 min.
Elongation in 2 inches	0.14	0.17	
Elongation, %	7.0	8.5	Info only
Fracture Location	H A Z	HAZ	---

BEND TESTS

Number	Type of Bend	Results
1	Face	No defects, Satisfactory
2	Face	No defects, Satisfactory
3	Root	1 crack 3/64", Satisfactory
4	Root	No defects, Satisfactory

NORTHWEST LABORATORIES

ALBERT O. WAHTO, PE

NORTHWEST LABORATORIES

of Seattle, Incorporated

ESTABLISHED 1896

Technical Services for: Industry, Commerce, Legal Profession & Insurance Industry

1530 FIRST AVENUE SOUTH SEATTLE, WASHINGTON 98134 Telephone: (206) 622-0680

Report To: Todd Pacific Shipyards Corp. Date: June 17, 1983

Report On: Aluminum Welds, PO PS81431 Lab No: E 28426-4

IDENTIFICATION:

Test No. A2.5 Overhead
Base Material & Temper 5086-H32 QQ-A-250/7
Material Thickness - 0.063"
Filler Metal- 5556
Test Procedure - Mil-Std-248C

TEST RESULTS:

Bar Number	T1	T2	Specified
Measurements	0.052 X 1.506	0.052 X 1.507	
Area Sq. Inches	0.0783	0.0784	
Yield Strength, Lbs. Actual	1,830	1,830	
Yield Strength, PSI	23,370	23,340	Info only
Ultimate Load, Lbs.	2,780	2,920	
Tensile Strength, PSI	35,500	37,240	35,000 min.
Elongation in 2 inches	0.16	0.17	
Elongation, %	8.0	8.5	Info only
Fracture Location	HAZ	HAZ	---

BEND TESTS

Number	Type of Bend	Results
	Face	No defects, Satisfactory
1	Face	No defects, Satisfactory
	Root	No defects, Satisfactory
4	Root	No defects, Satisfactory

NORTHWEST LABORATORIES

ALBERT O. WAHTO, PE
Chief Testing Engineer

NORTHWEST LABORATORIES

of Seattle, Incorporated

ESTABLISHED 1896

Technical Services for: Industry, Commerce, Legal Profession & Insurance Industry

1530 FIRST AVENUE SOUTH SEATTLE, WASHINGTON 98134 Telephone: (206) 622-0680

Report To: Todd Pacific Shipyards Corp.

Date: June 17, 1983

Report On: Aluminum Welds, PO PS81431

Lab No: E 28426-5

IDENTIFICATION:

Test No. B1 .18 Vertical Up
Base Material & Temper 5086-H32 QQ-A-250/7
material Thickness - 0.1OO
Filler Metal- 5356
Test Procedure - Mil-Std-248C

TEST RESULTS :

Bar Number	T1	T2	Specified
Measurements	0.089 X 1.509	0.091 X 1.509	
Area Sq. Inches	0.134	0.137	
Yield Strength, Lbs. Actual	2,700	2,960	
Yield Strength, PSI	20,150	21,610	Info only
Ultimate Load, Lbs.	4,700	4,940	
Tensile Strength, PSI	35,070	36,060	35,000 min.
Elongation in 2 inches	0.16	0.16	
Elongation, %	8.0	8.0	Info only
Fracture Location	Thru Weld.	Thru Meld	

BEND TESTS

Number	Type of Bend	Results
1	Face	No defects, Satisfactory
2	Face	No defects, Satisfactory
3	Root	No defects, Satisfactory
4	Root	No defects, Satisfactory

NORTHWEST LABORATORIES

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1530 FIRST AVENUE SOUTH l SEATTLE, WASHINGTON 98134 l Telephone: (206) 622-0680

Report To: Todd Pacific Shipyards Corp. Date: June 24, 1983

Report On: Aluminum Welds, PO PS 81431 Lab No: E 28426-6

IDENTIFICATION:

Test No. B50 Horizontal
Base Material and Temper - 5086 H-32 QQ-A-250/7
Material Thickness - 0.100"
Filler Metal - 5356
Test Procedure - Mil-Std-248C

TEST RESULTS:

Bar Number	T1	T2	Specified
Measurements	0.092 x 1.511	0.090 x 1.511	
Area Sq. Inches		0.136	
Yield Strength, Lbs. Actual	2,900	2,840	
Yield Strength, PSI	20,860	20,880	Info only
Ultimate Load, Lbs.	4,910	4,870	
Tensile Strength, PSI	35,320	35,810	35,000 min.
elongation in 2 Inches	0.16	0.16	
Elongation, %	8.0	8.0	Info only
Fracture Location	Thru Weld	Thru Weld	

BEND TESTS:

Number	Type of Bend	Results
1	Face	No defects, Satisfactory
2	Face	No defects, Satisfactory
1	Root	No defects, Satisfactory
2	Root	No defects, Satisfactory

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Report To: Todd Pacific Shipyards Corp. Date: June 17, 1983

Report On: Aluminum Welds, PO PS81431 Lab No: E 28426-7

IDENTIFICATION :

Test No. B74 Overhead
Base Material & Temper 5086-H32 QQ-A-250/7
Material Thickness - 0.100"
Filler Metal- 5356
Test Procedure - Mil-Std-248C

TEST RESULTS:

Bar Number	T1	T2	Specified
Measurements	0.088 X 1.511	0.089 X 1.510	
Area Sq. Inches	0.133	0.135	
Yield Strength, Lbs. Actual	3,040	3,170	
Yield Strength, PSI .	22,860	23,480	Info only
Ultimate Load, Lbs.	4,860	5,060	
Tensile Strength, PSI	36,540	37,480	35,000 min.
Elongation in 2 inches	0.18	0.18	
Elongation, %	9.0	9.0	Info only
Fracture Location	Thru weld	Thru weld	---

BEND TESTS

Number	Type of Bend	Results
	Face	No defects, Satisfactory
2	Face	No defects, Satisfactory
	Root	No defects, Satisfactory
4	Root	No defects, Satisfactory

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Report To: Todd Pacific Shipyards — Date: June 28, 1983

Report On: Aluminum Welds, PO PS 81431 — Lab No: E 28426-10

IDENTIFICATION:

Test No. C60 Vertical Up
Base Material & Temper - 5083-H323 QQ-A-250/6
Material Thickness - 0.125″
Filler Metal - 5556
Test Procedure Mil-Std-248C

TEST RESULTS:

Bar Number	T1	T2	Base Metal Actual Tests
Measurements	0.113 x 1*510	0.113 x 1.511	
Area Sq. Inches	0.171	0.171	
Yield Strength, Lbs. Actual	3,710	3,800	
Yield Strength, PSI	21,700	22,220	26,430
Ultimate Load, Lbs.	6,520	6,410	
Tensile Strength, PSI	38,130	37,480	41,460
Elongation in 2 Inches	0.24	0.24	
Elongation, %	12.0	12.0	19.5
Fracture Location	Thru Weld	Thru HAZ	

BEND TESTS

Number	Type of Bend	Results
	Face	No defects, Satisfactory
2	Face	No defects, Satisfactory
	Root	No defects, Satisfactory
2	Root	No defects, Satisfactory

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Report To: Todd Pacific Shipyards Date: June 28, 1983

Report On: Aluminum Welds, PO PS 81431 Lab No: E 28426-11

IDENTIFICATION:

Test No. C63 Vertical Up
Base Material & TemUer - 5083 -H323 QQ-A-250/6
Material Thickness - 0.125"
Filler Metal - 5356
Test Procedure Mil-Std-248C

TEST RESULTS:

Bar Number	T1	T2	Base Metal Actual Tests
Measurements	0.113 X 1.510	0.110 X 1.512	
Area Sq. Inches	0.171	0.166	
Yield Strength, Lbs. Actual	4,040	3,680	
Yield Strength, PSI	23,630	22,170	26,430
Ultimate Load, Lbs.	6,400	6,300	
Tensile Strength, PSI	37,430	37,950	41,460
Elongation in 2 Inches	0.23	0.20	
Elongation, %	11.5	10.0	19.5
Fracture Location	Thru Weld	Thru Weld	

BEND TESTS

Number	Type of Bend	Results
1	Face	No defects, Satisfactory
2	Face	No defects, Satisfactory
	Root	No defects, Satisfactory
2	Root	No defects, Satisfactory

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Report To: Todd Pacific Shipyards — Date: June 28, 1983

Report On: Aluminum Welds, PO PS 81431 — Lab No: E 28426-8

IDENTIFICATION:

Test No. C30 Horizontal
Base Material & Temper- 5083-H323 QQ-A-250/6
Material Thickness - 0.125″
Filler Metal - 5556
Test Procedure Mil-Std-248C

TEST RESULTS:

Bar Number	T1	T2	Base Metal Actual Tests
Measurements	0.115 x1.507	0.116 X 1.507	
Area Sq. Inches	0.173	0.175	
Yield Strength, Lbs. Actual	3,810	3,615	
Yield Strength, PSI	22,020	20,660	26,430
Ultimate Load, Lbs.	6,400	6,360	
Tensile Strength, PSI	36,990	36,340	41,460
Elongation in 2 Inches	0.24	0.24	
Elongation, %	12.0	12.0	19.5
Fracture Location	Thru Weld	Thru Weld	

BEND TESTS

Number	Type of Bend	Results
1	Face	No defects, Satisfactory
2	Face	No defects, Satisfactory
1	Root	No defects, Satisfactory
2	Root	No defects, Satisfactory

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Report To: Todd Pacific Shipyards   Date: June 28, 1983

Report On: Aluminum Welds, PO PS 81431   Lab No: E 28426-9

IDENTIFICATION:

Test No. C46 Overhead
Base Material & Temper - 5083 -H323 QQ-A-250/6
Material Thickness - 0.125"
Filler Metal - 5356
Test Procedure Mi1-Std-248C

TEST RESULTS :

Bar Number	T1	T2	Base Metal Actual Tests
Measurements	0.117 x 1.512	0.107 x 1.510	
Area Sq. Inches	0.177	0.162	
Yield Strength, Lbs. Actual	3,940	3,640	
Yield Strength, PSI	22,260	22,470	26,430
Ultimate Load, Lbs.	6,650	6,160	
Tensile Strength, PSI	37,570	38,020	41,460
Elongation in 2 Inches	0.24	0.20	
Elongation, %	12.0	10.0	19.5
Fracture Location	Thru Weld	Thru Weld	

BEND TESTS

Number	Type of Bend	Results
	Face	No defects, Satisfactory
1	Face	No defects, Satisfactory
1	Root	No defects, Satisfactory
2	Root	No defects, Satisfactory

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Report To: Todd Pacific Shipyards Corp. Date: June 20, 1983

Report On: Aluminum, PO PS 81458 Lab No: E 28495-2

IDENTIFICATION:

0.125” thick 5083 -H323 Aluminum Al1oy
QQ-A-250/6F

TEST RESULTS:

Bar Number	T1	T2	Specified
Measurements	0.127 x 1.507	0.128 x 1.510	
Area Sq. Inches	0.191	0.193	
Yield Strength, Lbs. Actual	5,050	5,100	
Yield Strength, PSI	26,440	26,420	34,000-44,000
Ultimate Load, Lbs.	7,960	7,960	
Tensile Strength, PSI	41,680	41,240	45,000-54,000
Elongation in 2 Inches	0.39	0.39	
Elongation, %	19.5	19.5	8 min.

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Report To: Todd Pacific Shipyards Corp. Date: June 17, 1983

Report On: Aluminum Welds, PO PS81431 Lab No: E 28426-12

IDENTIFICATION:

Test No. D8 Vertical Up
Base Material & Temper 5086-H116 QQ-A-250/l 9
Material Thickness - 0.250"
Filler Metal- 5556
Test Procedure - Mil-Std-248C

TEST RESULTS:

Bar Number	T1	T2	Specified
Measurements	0.228 X 1.505	0.240 X 1.505	
Area Sq. Inches	0.343	0.361	
Yield Strength, Lbs. Actual	7,250	7,300	
Yield Strength, PSI	21,140	20,220	Info only
Ultimate Load, Lbs.	12,400	13,600	
Tensile Strength, PSI	36,150	37,670	35,000 min.
Elongation in 2 inches	0.16	0.21	
Elongation, %	8.0	10.5	Info only
Fracture Location	Thru Weld	Thru Weld	---

BEND TESTS

Number	Type of Bend	Results
	Face	4 cracks 1/32", Satisfactory
2	Face	No defects, Satisfactory
	Root	No defects, Satisfactory
4	Root	No defects, Satisfactory

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Report To: Todd Pacific Shipyards Date: July 7, 1983

Report On: Aluminum Welds, PO PS 8145B Lab No: E 28635-3

IDENTIFICATION:

Test No. D-10 Horizontal
Base Material & Temper - 5086 - H116 QQ-A-250/19
Material Thickness - 0.250″
Filler Metal- 5556
Test Procedure - Mil-Std-248C

TEST RESULTS:

Bar Number	T1	T2	Specified
Measurements	0.236 X 1.510	0.237 X 1.509	
Area Sq. Inches	0.356	0.358	
Yield Strength, Lbs. Actual	7,000	6,700	
Yield Strength, PSI	19,660	18,710	Info only
Ultimate Load, Lbs.	14,150	14,200	
Tensile Strength, PSI	39,750	39,660	35,000 min.
Elongation in 2 Inches	0.26	0.29	
Elongation, %	13.0	14.5	Info only
Fracture Location	Thru Weld	Thru Weld	

B END TESTS:

Number	Type of Bend	Results
	Face	No defects, Satisfactory
1	Face	No defects, Satisfactory
	Root	No defects, Satisfactory
2	Root	No defects, Satisfactory

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Report To: Todd Pacific Shipyards Date: July 7, 1983

Report On: Aluminum welds, PO PS 8145B Lab No: E 28635-2

IDENTIFICATION:

Test No. E-33 Horizontal
Base Material & Temper - 5456 - Hll6 QQ-A-250/7
Material Thickness - 0.250"
Filler Metal- 5556
Test Procedure - Mil-Std-248C

TEST RESULTS:

Bar Number	Tl	T2	Specified
Measurements	0.245 X 1.506	0.246 X 1.506	
Area Sq. Inches	0.369	0.369	
Yield Strength, Lbs. Actual	8,700	9,250	
Yield Strength, PSI	23,580	25,070	Info only
Ultimate Load, Lbs.	15,600	15,800	
Tensile Strength, PSI	42,280	42,820	42,000 min.
elongation in 2 Inches	0.19	0.20	
Elongation, %	9.5	10.0	Info only
Fracture Location	Thru Weld	Thru Weld	

BEND TESTS:

Number	Type of Bend	Results
	Face	No defects, Satisfactory
1	Face	No defects, Satisfactory
1	Root	No defects, Satisfactory
2	Root	No defects, Satisfactory

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Report To: Todd Pacific Shipyards Corp. Date: June 24, 1983

Report On: Aluminum Welds, PO PS 81431 Lab No: E 28426-14

IDENTIFICATION:

Test No. F3 - Vertical Up
Base Material and Temper- 5083-H321 *QQ-A-250/6*
Material Thickness - 0.250″
Filler Metal - 5556
Test Procedure - Mil-Std-248C

TEST RESULTS:

Bar Number	T1	T2	Specified
Measurements	0.230 X 1.503	0.236 X 1.512	
Area Sq. Inches	0.346	0.356	
Yield Strength, Lbs. Actual	7,260	7,930	
Yield Strength, PSI	20,980	22,280	Info only
Ultimate Load, Lbs.	14,000	15,150	
Tensile Strength, PSI	40,460	42,560	40,000 min.
elongation in 2 Inches	0.17	0.21	
Elongation, %	8.5	10.5	Info only
Fracture Location	Thru Weld	Thru Weld	

BEND TESTS:

Number	Type of Bend	Results
1	Face	No defects, Satisfactory
2	Face	1 crack 1/16″, Satisfactory
1	Root	1 crack 3/32″, Satisfactory
2	Root	No defects, Satisfactory

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Report To: Todd Pacific Shipyards Date: July 7, 1983

Report On: Aluminum Wel ds, PO PS 8145B Lab No: E 28635-1

IDENTIFICATION:

Test No. F-13 Horizontal
Base Material & Temper - 5083 - H321 QQ-A-250/6
Material Thickness - 0.250"
Filler Metal- 5556
Test Procedure - Mil-Std-248C

TEST RESULTS:

Bar Number	T1	T2	Specified
Measurements	0.243 X 1.508	0.234 X 1.508	
Area Sq. Inches	0.366	0.353	
Yield Strength, Lbs. Actual	7,420	8,300	
Yield Strength, PSI	20,270	23,510	Info only
Ultimate Load, Lbs.	15,350	14,850	
Tensile Strength, PSI	41,940	42,070	40,000 min.
Elongation in 2 Inches	0.26	0.23	
Elongation, %	13.0	11.5	Info only
Fracture Location	Thru Weld	Thru Weld	

BEND TESTS:

Number	Type of Bend	Results
1	Face	No defects, Satisfactory
2	Face	No defects, Satisfactory
1	Root	No defects, Satisfactory
2	Root	No defects, Satisfactory

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1530 FIRST AVENUE SOUTH l SEATTLE, WASHINGTON 98134 l Telephone: (206) 622-0680

Report To: Todd Pacific Shipyards   Date: November 1, 1983

Report On: Welds PO PS 81723   Lab No: E 29361

IDENTIFICATION:

Set No. 1-10
Base material 5083-H321 for QQ-A-250/6 1/2″ thick plate
Filler Material - 5356 position- flat Mechanized
Tested per Mil-Std-248C

TEST RESULTS :

Tensile Test

Bar #	T1	T2	S~ecified
Measurements	1.497 *X* .467	1.497 x .474	
Area Sq. Inches	.699	.710	
Yield Strength, Lbs. Actual	14,250	14,340	
Yield Strength, PSI	20,390	20,200	Info. Only
Ultimate Load, Lbs.	28,550	28,470	
Tensile Strength, PSI	40,840	40,100	40,000 Min.
Elongation In 2 Inches	.29	.22	
Elongation, %	14.5	11.0	Info. Only
Fracture Location	Thru weld	Thru weld	--

Bend Tests

No.	Type of Bend	Results
F1	Face	3 cracks 1/64″ Satisfactory
F2	Face	Cracks 1/64″ to 1/32″ Satisfactory
R1	Root	No Defects Satisfactory
R2	Root	No Defects Satisfactory

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AUG 26 1983
TODD PACIFIC
SHIPYARDS
WELDING
ENGINEERING

August 25, 1983

Todd Shipbuilding & Construction Co.
P.O. Box 3806
Seattle, WA 98124
Attn: Mike Nakata

Dear Sir:

This is to certify that the aluminum weld test coupons were tested on our Tinius Olson Super "L" Universal Testing Machine calibrated one step removed from the National Bureau of Standards. Calibrated on April 8, 1983 by Pacific Scientific Company.

ALBERT O. WAHTO, PE
Chief Testing Engineer
License No. 3004

AOW:lb

TYPICAL	TEST NUMBER & WELD POSITION	BASE MATERIAL	TEMPER	BASE MATERIAL THICKNESS	FEDERAL SPECIFICATION	X-RAY RESULTS	PENETRANT RESULTS	FACE BEND	ROOT BEND	TENSILE 1 PSI	TENSILE 2 PSI	SPECIFIED * TENSILE	COMMENTS
A1.14	HORIZONTAL	5086	H-32	.063"	QQ-A-250/7	ACCEPT	ACCEPT	ACCEPT	ACCEPT	37,020	35,200	35,000	ACCEPTAB
A1.3	VERTICAL-UP	5086	H-32	.063"	QQ-A-250/7	ACCEPT	ACCEPT	ACCEPT	ACCEPT	35,990	35,860	35,000	ACCEPTAB
A1.23	VERTICAL-UP	5086	H-32	.063"	QQ-A-250/7	ACCEPT	ACCEPT	ACCEPT	ACCEPT	36,750	37,400	35,000	ACCEPTAB
A2.5	OVERHEAD	5086	H-32	.063"	QQ-A-250/7	ACCEPT	ACCEPT	ACCEPT	ACCEPT	35,500	37,240	35,000	ACCEPTAB
B1.18	VERTICAL-UP	5086	H-32	.100"	QQ-A-250/7	ACCEPT	ACCEPT	ACCEPT	ACCEPT	35,070	36,060	35,000	ACCEPTAB
B.74	OVERHEAD	5086	H-32	.100"	QQ-A-250/7	ACCEPT	ACCEPT	ACCEPT	ACCEPT	36,540	37,480	35,000	ACCEPTAB
B.50	HORIZONTAL	5086	H-32	.100"	QQ-A-250/7	ACCEPT	ACCEPT	ACCEPT	ACCEPT	35,320	35,810	35,000	ACCEPTAB
C.30	HORIZONTAL	5083	H-323	.125"	QQ-A-250/6	ACCEPT	ACCEPT	ACCEPT	ACCEPT	34,990	36,340	40,000	1
C.46	OVERHEAD	5083	H-323	.125"	QQ-A-250/6	ACCEPT	ACCEPT	ACCEPT	ACCEPT	37,570	38,020	40,000	1
C.60	VERTICAL-UP	5083	H-323	.125"	QQ-A-250/6	ACCEPT	ACCEPT	ACCEPT	ACCEPT	38,130	37,480	40,000	1
C.63	VERTICAL-UP	5083	H-323	.125"	QQ-A-250/6	ACCEPT	ACCEPT	ACCEPT	ACCEPT	37,430	37,950	40,000	1
D.8	VERTICAL-UP	5086	H-116	.250"	QQ-A-250/19	ACCEPT	ACCEPT	ACCEPT	ACCEPT	36,150	37,670	35,000	ACCEPTAB
F.3	VERTICAL-UP	5083	H-321	.250"	QQ-A-250/6	ACCEPT	ACCEPT	ACCEPT	ACCEPT	40,460	42,560	40,000	ACCEPTAB
E.13	HORIZONTAL	5083	H-321	.250"	QQ-A-250/6	ACCEPT	ACCEPT	ACCEPT	ACCEPT	41,940	42,070	40,000	ACCEPTAB
E.33	HORIZONTAL	5456	H-116	.250"	QQ-A-250/7	ACCEPT	ACCEPT	ACCEPT	ACCEPT	42,280	42,820	42,000	ACCEPTAB
D.10	HORIZONTAL	5086	H-116	.250"	QQ-A-250/19	ACCEPT	ACCEPT	ACCEPT	ACCEPT	39,750	39,660	35,000	ACCEPTAB

Calc.			REVISED	DATE	ALUMINUM WELDING, ONE-SIDE, OUT-OF-POSITION, FULL PENETRATION, MANUAL GAS METAL ARC BUTT WELDING OF 5000 SERIES ALUMINUM ALLOY SHEET & PLATE
Trac					
Chk					
Appr.					TODD PACIFIC SHIPYARD CORP., SEATTLE DIVISION
Appr.					

WE004
3/83

DATA SHEET

FIGURE 71
MECHANICAL PROPERTIES DATA
* "O" TEMPER

1 LOW BASE METAL TENSILE STRENGTH: 0.125" THICK 5083-H323
YIELD STRENGTH 26,430 PSI ACTUAL INSTEAD OF 34,000-44,000PSI
TENSILE STRENGTH 41,460 PSI ACTUAL INSTEAD OF 45,000-54,000 P

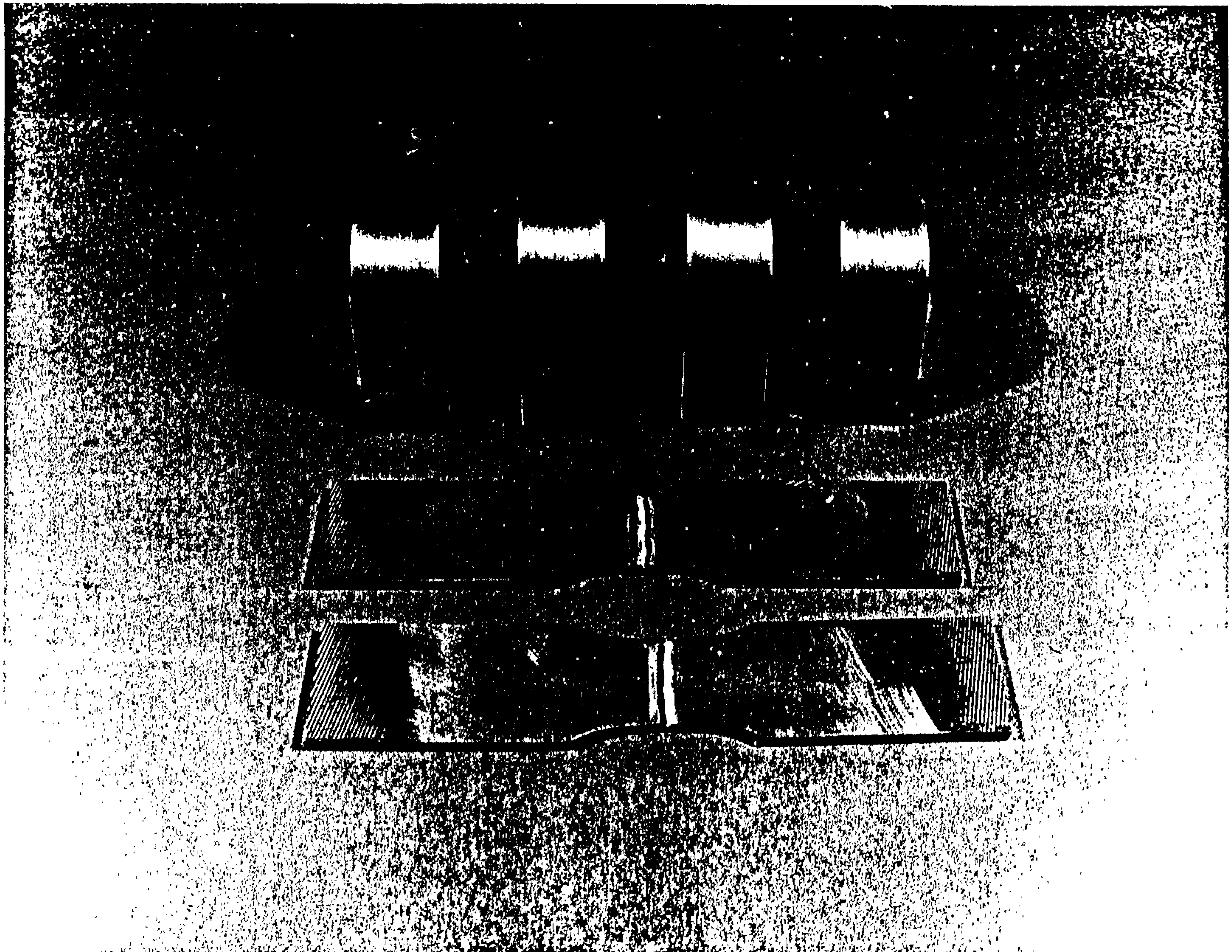


FIGURE 72
TYPICAL MECHANICAL PROPERTIES TEST SPECIMENS AFTER TENSILE AND BEND TESTS

FIGURE 73

LAY-OUT OF TYPICAL MECHANICAL PROPERTIES TEST SPECIMENS SUBSEQUENT TO TENSILE & BEND TESTING

PULSE ARC WELDING MACHINE SETTINGS

Pulse arc welding machine settings that were determined and established during this program are shown in a summary page form and also in individual machine setting forms. These machine settings represent actual values developed during the course of this investigation and apply primarily to butt welding in the out-of-position, one-side, full penetration manual gas metal arc welding of 5000 series aluminum alloy sheet and plates. These values provide excellent starting weld parameters and should be adjusted accordingly for other weld joint designs and other marine aluminum alloys.

Charts showing wire feed speeds (inches per minute) vs. wire speed dial settings have been developed for the Airco System 1, Airco AHF-NP, Gilliland MTG 4001 and the M & K wire feeders. It is anticipated that these charts would be helpful in the developmental determination of individual machine settings.

The following information covering pulse arc welding machine settings are divided into three sections: Airco PA-3A & PA-350, Gilliland CV-600 FI-PA, and the Miller Pulstar 450. Each section includes a matrix of machine settings, wire feed speeds vs. dial settings and individually developed detailed weld machine settings.

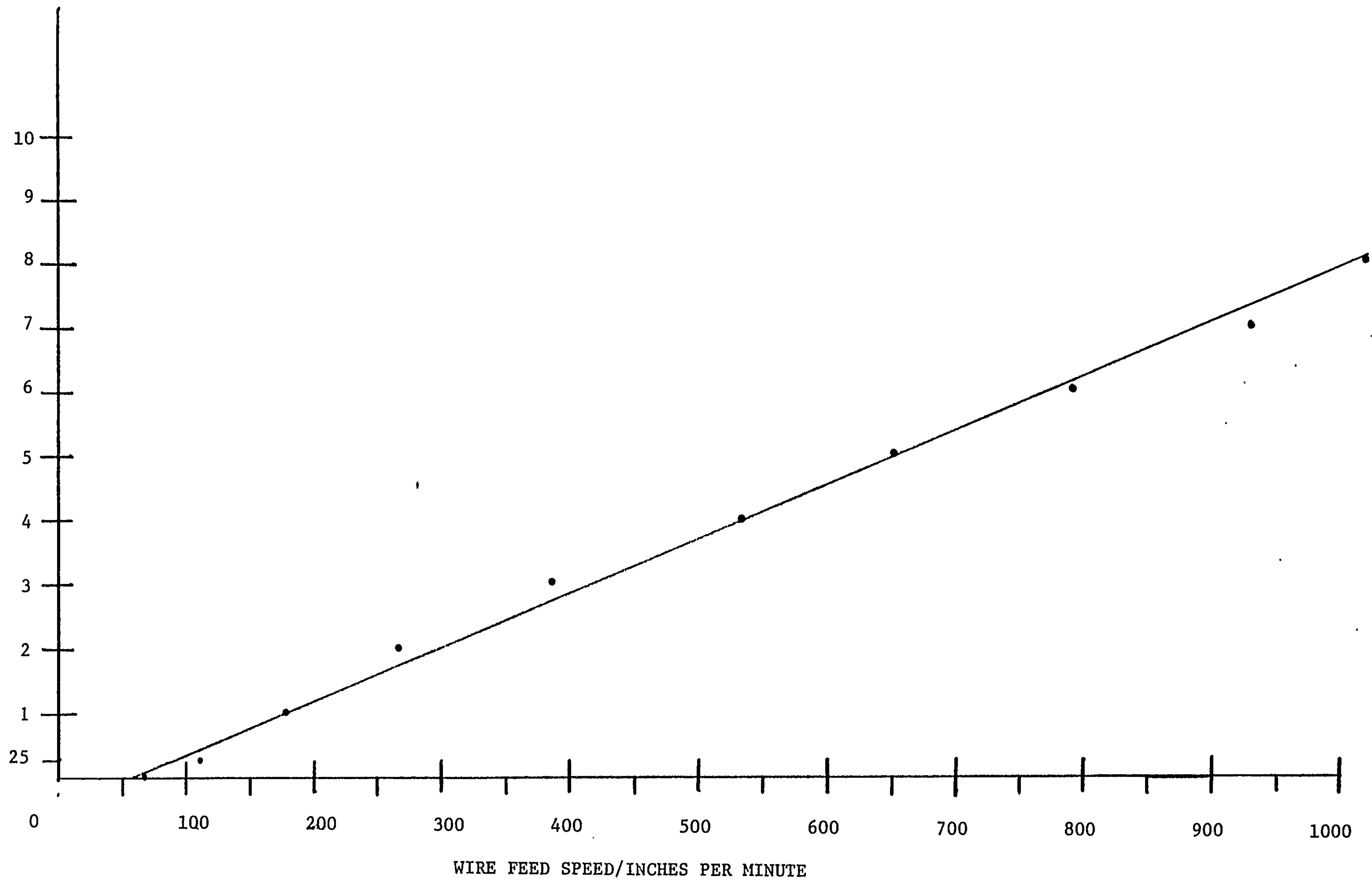
*　　*　　*　　*　　*　　*

WELDING POSITION

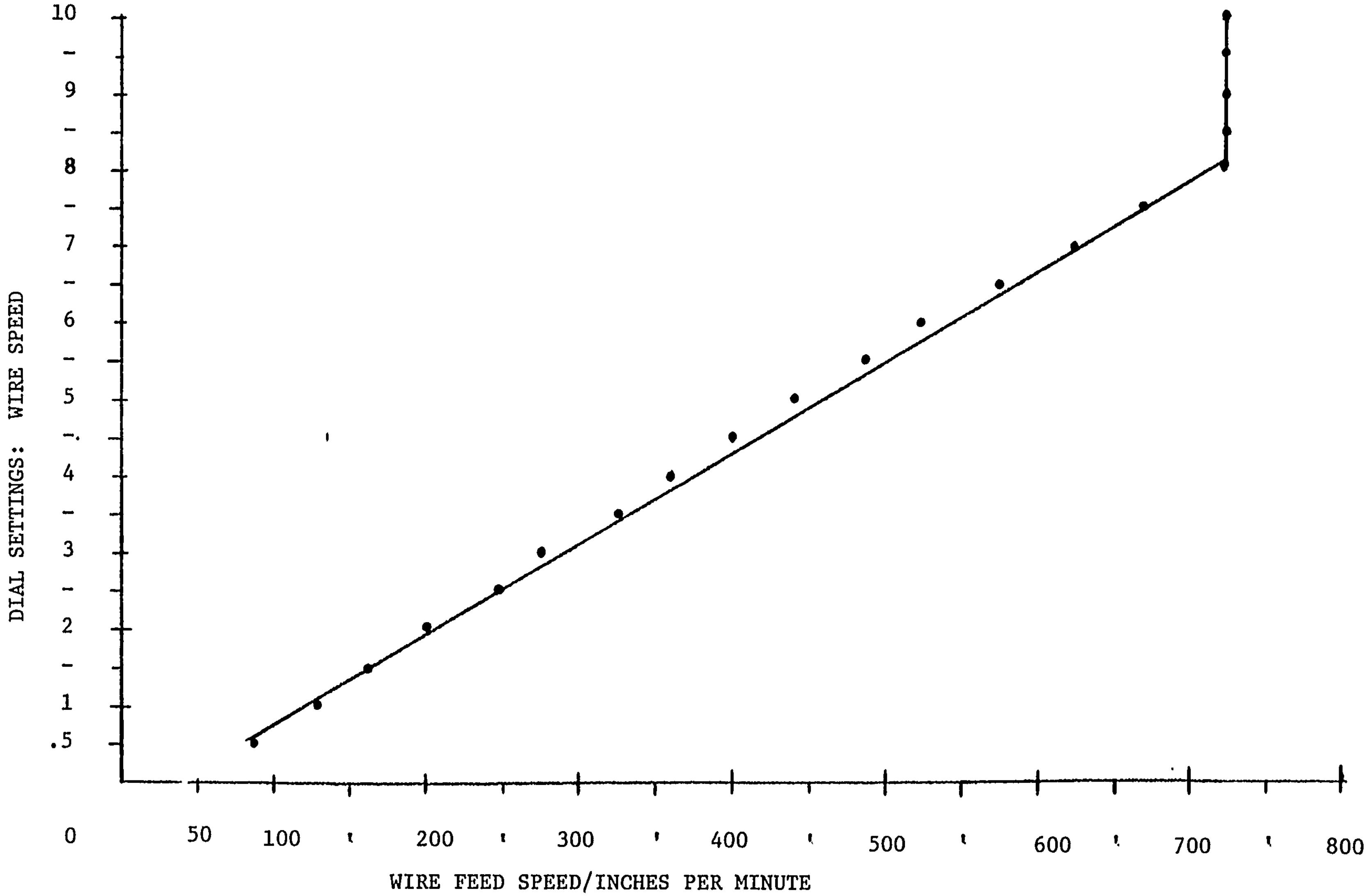
BASE MATERIAL ALLOY		FILLER WIRE ALLOY	VERTICAL-UP				HORIZONTAL				OVERHEAD				FLAT			
			030	.035	3/64	1/16	030	.035	3/64	1/16	030	.035	3/64	1/16	030	.035	3/64	1/16
A	.063" 5086 H-32	5356		XX	XX												XX	
		5556			XX				XX				XX					
B	.100" 5086 H-32	5356	XX	XX				XX					XX				XX	
		5556		XX														
C	.125" 5083 H-323	5356		XX	XX								XX				XX	
		5556		XX	XX			XX	XX								XX	
D	.250" 5086 H-116	5356											XX				XX	
		5556			XX				XX.								XX	
E	.250" 5456 H-116	5356											XX				XX	
		5556			XX				XX									
F	.250" 5083 H-321	5356											XX				XX	
		5556			XX				XX								XX	
G	.500" 5086 H-116	5356			XX				XX				XX				XX	
		5556											XX					
H	.500" 5456 H-116	5356			XX				XX				XX				XX	
		5556																
I	.500" 5083 H-321	5356			XX				XX				XX				XX	
		5556																

FILLER WIRE DIAMETER
(INCH)

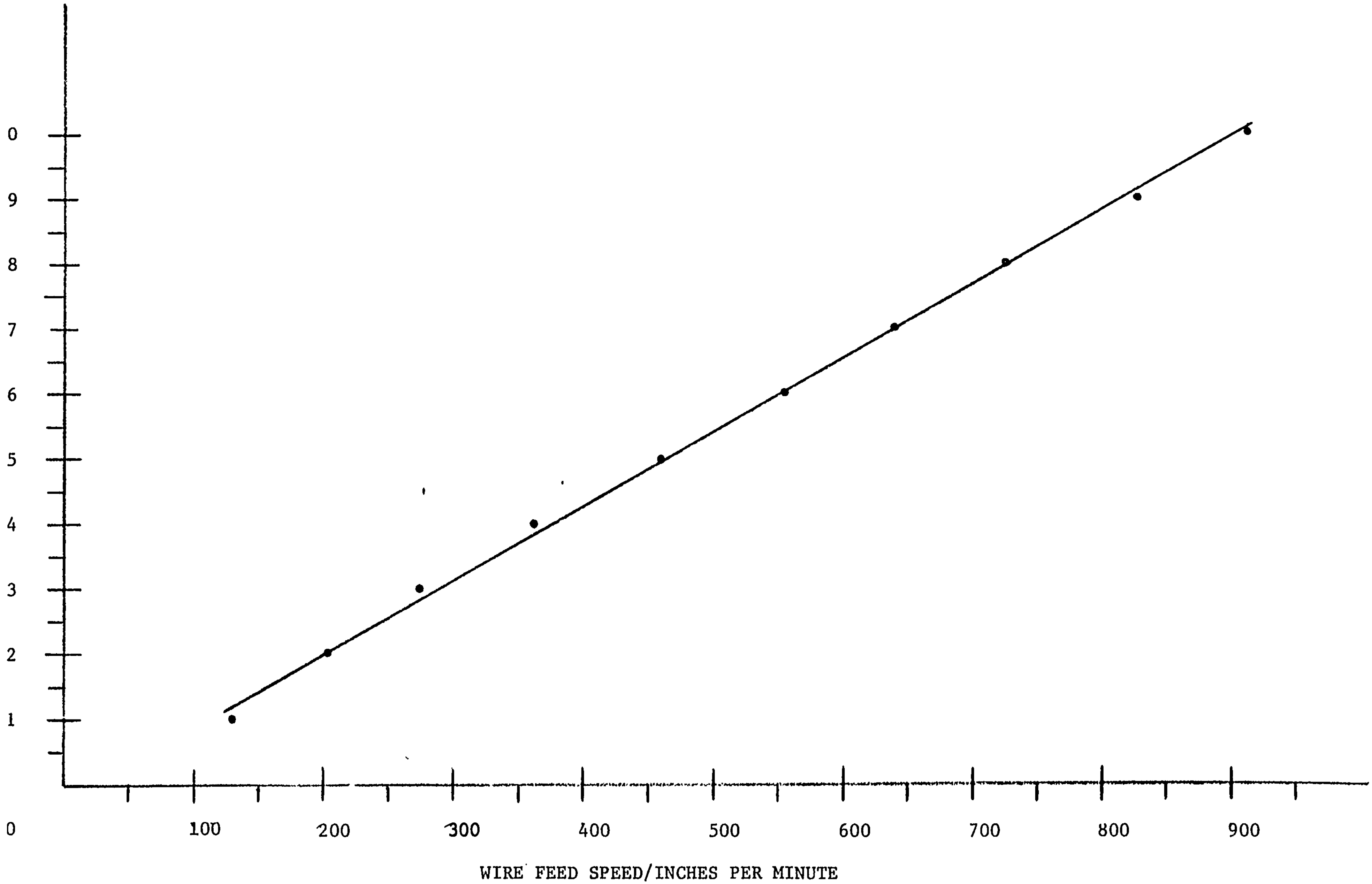
OVERALL MACHINE SETTING MATRIX



WIRE FEED SPEED VS. DIAL SETTINGS
3/64" DIAMETER 5356 ALUMINUM ALLOY FILLER WIRE
AIRCO AHF-NP FEEDER; AH 35-C2/GUN



WIRE FEED SPEED VS. DIAL SETTINGS
3/64" DIAMETER 5556 ALUMINUM ALLOY FILLER WIRE
AIRCO SYSTEM 1 FEEDER; AIRCOMATIC GUN: MANUAL MODE



WIRE FEED SPEED VS. DIAL SETTINGS
.035" DIAMETER 5356 ALUMINUM ALLOY FILLER WIRE
AIRCO SYSTEM 1 FEEDER; AIRCOMATIC GUN: MANUAL MODE

WELDING POSITION

BASE MATERIAL ALLOY		VERTICAL-UP				HORIZONTAL				OVERHEAD				FLAT				FILLER WIRE ALLOY
		030	.035	3/64	1/16	030	.035	3/64	1/16	030	.035	3/64	1/16	030	.035	3/64	1/16	
A	.063" 5086 H-32			XX														5356
				XX				XX				XX						5556
B	.100" 5086 H-32	XX*					XX*					XX						5356
																		5556
C	.125" 5083 H-323			XX								XX						5356
				XX				XX										5556
D	.250" 5086 H-116											XX				XX		5356
				XX				XX										5556
E	.250" 5456 H-116											XX				XX		5356
				XX				XX										5556
F	.250" 5083 H-321											XX				XX		5356
				XX				XX										5556
G	.500" 5086 H-116			XX				XX				XX				XX		5356
												XX						5556
H	.500" 5456 H-116			XX				XX				XX				XX		5356
																		5556
I	.500" 5083 H-321			XX				XX				XX						5356
																		5556

*PA-3A

FILLER WIRE DIAMETER (INCH)

AIRCO-MACHINE SETTING MATRIX

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
			CO_2	AR/CO_2
.063" THICKNESS 5086 H-32 ALUMINUM ALLOY	5556 ALUMINUM ALLOY 3/64" DIAMETER			X

SHIELD GAS		FLOW RATE
75%HE/25%AR X		40 CFH

PUSHBUTTONSELECTOR SWITCHES

1	2	3	4
[redacted] OUT	IN [redacted]	IN [redacted]	[redacted] OUT

WELDING VOLTAGE		15	BACKGROUND SETTING		
WELDING CURRENT AMPS		50			
REMOTE PENDANT	CURRENT SETTING	2.25	WIRE FEED PROCESS	AUTO	
				MANUAL	X
	VOLTAGE TRIM SETTING	.5			
WIRE SPEED-IPM		125	POTENTIOMETER SETTING 1.0		
TRAVEL SPEED-IPM		18			

A1.3
VERTICAL-UP

AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
			CO_2	AR/CO_2
.063" THICKNESS 5086 H-32 ALUMINUM ALLOY	5356 ALUMINUM ALLOY 3/64" DIAMETER			X

SHIELD GAS		FLOW RATE
75%HE/25%AR X		40 CFH

PUSHBUTTON SELECTOR SWITCHES

1		2		3		4	
	OUT	IN		IN			OUT

WELDING VOLTAGE	15.5	BACKGROUND SETTING	
WELDING CURRENT AMPS	40		
REMOTE PENDANT: CURRENT SETTING	2.25	WIRE FEED PROCESS	AUTO
			MANUAL X
REMOTE PENDANT: VOLTAGE TRIM SETTING	.5		
WIRE SPEED-IPM	172	POTENTIOMETER SETTING	1.5
TRAVEL SPEED-IPM	18.4		

A1.23
VERTICAL-UP

AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
			CO_2	AR/CO_2
.063" THICKNESS 5086 H-32 ALUMINUM ALLOY	5556 ALUMINUM ALLOY 3/64" DIAMETER			X

SHIELD GAS		FLOW RATE
75%HE/25%AR X		40 CFH

PUSHBUTTON SELECTOR SWITCHES

1	2	3	4
[redacted] OUT	IN [redacted]	IN [redacted]	[redacted] OUT

WELDING VOLTAGE		15	BACKGROUND SETTING		
WELDING CURRENT AMPS		50			
REMOTE PENDANT	CURRENT SETTING	2.75	WIRE FEED PROCESS	AUTO	
				MANUAL	X
	VOLTAGE TRIM SETTING	.5			
WIRE SPEED-IPM		168	POTENTIOMETER SETTING	1.4	
TRAVEL SPEED-IPM		18			

A 1.14
HORIZONTAL

AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
			CO_2	AR/CO_2
.063" THICKNESS 5086 H-32 ALUMINUM ALLOY	5556 ALUMINUM ALLOY 3/64" DIAMETER			X

SHIELD GAS		FLOW RATE
75%HE/25%AR X		40 CFH

PUSHBUTTON SELECTOR SWITCHES

1	2	3	4
OUT	IN	IN	OUT

WELDING VOLTAGE		15.5	BACKGROUND SETTING		
WELDING CURRENT AMPS		50			
REMOTE PENDANT	CURRENT SETTING	2.5	WIRE FEED PROCESS	AUTO	
				MANUAL	X
	VOLTAGE TRIM SETTING	5			
WIRE SPEED-IPM		155	POTENTIOMETER SETTING	1.35	
TRAVEL SPEED-IPM		20			

A2.5
OVERHEAD

AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PULSE PROCESS SELECTOR	
		120	60
.100" THICKNESS 5086 H-32 ALUMINUM ALLOY	5356 ALUMINUM ALLOY .030" DIAMETER	X	

SHIELD GAS		FLOW RATE
75%HE/25%AR		40 CFH

SELECTOR SWITCHES	
EXTRA LOW ON ON- -OFF ■ ■ □	NORMAL

WELDING VOLTAGE	19		
WELDING CURRENT AMPS	45		
CURRENT SETTING			
VOLTAGE SETTING		BACKGROUND 43	PEAK 64
WIRE SPEED-IPM	301	POTENTIOMETER SETTING 3.9	
TRAVEL SPEED-IPM	15.6		

B1.18
VERTICAL-UP

AIRCO PA-3A MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PULSE PROCESS SELECTOR	
.100" THICKNESS 5086 H-32 ALUMINUM ALLOY	5356 ALUMINUM ALLOY .035" DIAMETER	120	60
		X	

SHIELD GAS		FLOW RATE
75%HE/25%AR		40 CFH

SELECTOR SWITCHES	
EXTRA LOW ON ON--OFF ■ ■ □	NORMAL

WELDING VOLTAGE	19		
WELDING CURRENT AMPS	55		
CURRENT SETTING			
VOLTAGE SETTING		BACKGROUND 43	PEAK 68
WIRE SPEED-IPM	260	POTENTIOMETER SETTING 3.6	
TRAVEL SPEED-IPM	18		

B.50
HORIZONTAL

AIRCO PA-3A MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
			CO_2	AR/CO_2
.100" THICKNESS 5086 H-32 ALUMINUM ALLOY	5356 ALUMINUM ALLOY 3/64" DIAMETER			X

SHIELD GAS		FLOW RATE
75%HE/25%AR		40 CFH

PUSHBUTTON SELECTOR SWITCHES

1	2	3	4
OUT	IN	IN	OUT

WELDING VOLTAGE		16	BACKGROUND SETTING		
WELDING CURRENT AMPS		70			
REMOTE PENDANT	CURRENT SETTING	4.0	WIRE FEED PROCESS	AUTO	
				MANUAL	X
REMOTE PENDANT	VOLTAGE TRIM SETTING	.5			
WIRE SPEED-IPM		205	POTENTIOMETER SETTING	2.0	
TRAVEL SPEED-IPM		17			

B.74
OVERHEAD

AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
			CO_2	AR/CO_2
.125" THICKNESS 5083 H-323 ALUMINUM ALLOY	5556 ALUMINUM ALLOY 3/64" DIAMETER			X

SHIELD GAS		FLOW RATE
75%HE/25%AR X		40 CFH

PUSHBUTTON SELECTOR SWITCHES

1		2		3		4	
[redacted]	OUT	IN	[redacted]	IN	[redacted]	[redacted]	OUT

WELDING VOLTAGE	17	BACKGROUND SETTING	
WELDING CURRENT AMPS	70		

REMOTE PENDANT	CURRENT SETTING	4.75	WIRE FEED PROCESS	AUTO	
				MANUAL	X
	VOLTAGE TRIM SETTING	.75			

WIRE SPEED-IPM	225	POTENTIOMETER SETTING	2.25
TRAVEL SPEED-IPM	12.8		

C.60
VERTICAL-UP

AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
			CO_2	AR/CO_2
.125" THICKNESS 5083 H-323 ALUMINUM ALLOY	5356 ALUMINUM ALLOY 3/64 "DIAMETER			X

SHIELD GAS		FLOW RATE
75%HE/25%AR X		40 CFH

PUSHBUTTON SELECTOR SWITCHES

1	2	3	4
OUT	IN	IN	OUT

WELDING VOLTAGE		17	BACKGROUND SETTING		
WELDING CURRENT AMPS		70			
REMOTE PENDANT	CURRENT SETTING	4.5	WIRE FEED PROCESS	AUTO	
				MANUAL	X
REMOTE PENDANT	VOLTAGE TRIM SETTING	.5			
WIRE SPEED-IPM		240	POTENTIOMETER SETTING	2.5	
TRAVEL SPEED-IPM		14.1			

C-63
VERTICAL-UP

AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
			CO_2	AR/CO_2
.125" THICKNESS 5083 H-323 ALUMINUM ALLOY	5556 ALUMINUM ALLOY 3/64" DIAMETER			X

SHIELD GAS		FLOW RATE
75%HE/25%ARX		40 CFH

~~PUSHBUTTON~~ SELECTOR SWITCHES

1		2		3		4	
[redacted]	OUT	IN	[redacted]	IN	[redacted]		OUT

WELDING VOLTAGE		19.5	BACKGROUND SETTING		
WELDING CURRENT AMPS		85			
REMOTE PENDANT	CURRENT SETTING	5.5	WIRE FEED PROCESS	AUTO	
				MANUAL	X
	VOLTAGE TRIM SETTING	1.0			
WIRE SPEED-IPM		245	POTENTIOMETER SETTING	2.5	
TRAVEL SPEED-IPM		15			

C.30
HORIZONTAL

AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
			CO_2	AR/CO_2
.125" THICKNESS 5083 H-323 ALUMINUM ALLOY	5356 ALUMINUM ALLOY 3/64" DIAMETER			X

SHIELD GAS		FLOW RATE
75%HE/25%AR		40 CFH

PUSHBUTTON SELECTOR SWITCHES

1	2	3	4
[redacted] OUT	IN [redacted]	IN [redacted]	[redacted] OUT

WELDING VOLTAGE		15	BACKGROUND SETTING		
WELDING CURRENT AMPS		105			
REMOTE PENDANT	CURRENT SETTING	4.0	WIRE FEED PROCESS	AUTO	
				MANUAL	X
	VOLTAGE TRIM SETTING	0			
WIRE SPEED-IPM		280	POTENTIOMETER SETTING	3.0	
TRAVEL SPEED-IPM		20			

C46
OVERHEAD

AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
			CO_2	AR/CO_2
.250" THICKNESS 5086 H-116 ALUMINUM ALLOY	5556 ALUMINUM ALLOY 3/64" DIAMETER			X

SHIELD GAS		FLOW RATE
75%HE/25%AR		40 CFH

PUSHBUTTON SELECTOR SWITCHES

1	2	3	4
OUT	IN	IN	OUT

WELDING VOLTAGE		16	BACKGROUND SETTING		
WELDING CURRENT AMPS		150			
REMOTE PENDANT	CURRENT SETTING	5.5	WIRE FEED PROCESS	AUTO	
				MANUAL	X
	VOLTAGE TRIM SETTING	.5			
WIRE SPEED-IPM		362	POTENTIOMETER SETTING	4.0	
TRAVEL SPEED-IPM		11.5			

D.8
VERTICAL-UP

1 PASS

AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
			CO_2	AR/CO_2
.250" THICKNESS 5086-H116 ALUMINUM ALLOY	5556 ALUMINUM ALLOY 3/64" DIAMETER			X

SHIELD GAS		FLOW RATE
~~75%HE/25%AR~~	100% HE	100 CFH

PUSHBUTTON SELECTOR SWITCHES

1	2	3	4
OUT	IN	IN	OUT

WELDING VOLTAGE		14.5	BACKGROUND SETTING	NA	
WELDING CURRENT AMPS		149			
REMOTE PENDANT	CURRENT SETTING	4.25	WIRE FEED PROCESS	AUTO	
				MANUAL	X
	VOLTAGE TRIM SETTING	0			
WIRE SPEED-IPM		327	POTENTIOMETER SETTING	3.5	
TRAVEL SPEED-IPM		8.4			

D-10
HORIZONTAL

AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
.250" THICKNESS 5086 H-116 ALUMINUM ALLOY	3/64" DIAMETER 5356 ALUMINUM ALLOY	COVER X	CO_2	AR/CO_2 ROOT X

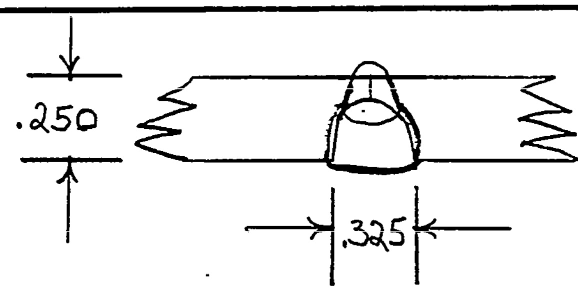
SHIELD GAS			FLOW RATE
75%HE/25%AR	X		40 CFH

"J" GROOVE

PUSHBUTTON SELECTOR SWITCHES

1	2	3	4
OUT	OUT	IN	OUT

POSITION		OVERHEAD		
WELDING VOLTAGE		14 26.2	BACKGROUND SETTING	0
WELDING CURRENT AMPS		158 118		
REMOTE PENDANT	CURRENT SETTING	4.5 5.0	WIRE FEED PROCESS	COVER AUTO X ROOT MANUAL X
	VOLTAGE TRIM SETTING	0 0		
WIRE SPEED-IPM		290 375	POTENTIOMETER SETTING	ROOT 4.0 COVER AUTO
TRAVEL SPEED-IPM		20.7 15.3		



D-35

AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
			CO_2	AR/CO_2
5086 H-116 .250" THICKNESS ALUMINUM ALLOY	3/64" DIAMETER 5356 ALUMINUM ALLOY	X		

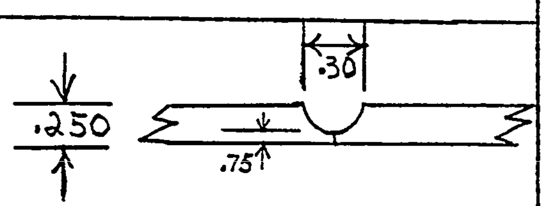
SHIELD GAS			FLOW RATE
75%HE/25%AR	X		40 CFH

"J" GROOVE

PUSHBUTTON SELECTOR SWITCHES

1	2	3	4
OUT	OUT	IN	OUT

POSITION		FLAT MECHANIZED				
WELDING VOLTAGE		24.8 26.5	BACKGROUND SETTING	0 0		
WELDING CURRENT AMPS		92 124				
REMOTE PENDANT	CURRENT SETTING	3.5 5.5	WIRE FEED PROCESS		AUTO	X
					MANUAL	
	VOLTAGE TRIM SETTING	0 0				
WIRE SPEED-IPM		234 314	POTENTIOMETER SETTING	0 0		
TRAVEL SPEED-IPM		12.2 16				
AUTO BUG-O		C.5 C.5				



D.28

AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
			CO_2	AR/CO_2
.250" THICKNESS 5456 H-116 ALUMINUM ALLOY	5556 ALUMINUM ALLOY 3/64" DIAMETER			X

SHIELD GAS		FLOW RATE
75%HE/25%AR X		40 – CFH

PUSHBUTTON SELECTOR SWITCHES

1	2	3	4
[redacted] OUT	IN [redacted]	IN [redacted]	[redacted] OUT

WELDING VOLTAGE		18	BACKGROUND SETTING		
WELDING CURRENT AMPS		115			
REMOTE PENDANT	CURRENT SETTING	5.5	WIRE FEED PROCESS	AUTO	
				MANUAL	X
	VOLTAGE TRIM SETTING	1.0			
WIRE SPEED-IPM		305	POTENTIOMETER SETTING	3.5	
TRAVEL SPEED-IPM		9.3			

E-7
VERTICAL-UP

1 PASS

AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
			CO_2	AR/CO_2
.250" THICKNESS 5456-H116 ALUMINUM ALLOY	5556 3/64" DIAMETER			X

SHIELD GAS		FLOW RATE
~~75%HE/25%AR~~	100% HE	100 CFH

PUSHBUTTON SELECTOR SWITCHES

1	2	3	4
OUT	IN	IN	OUT

WELDING VOLTAGE		14.5	BACKGROUND SETTING NA		
WELDING CURRENT AMPS		156			
REMOTE PENDANT	CURRENT SETTING	4.25	WIRE FEED PROCESS	AUTO	
				MANUAL	X
	VOLTAGE TRIM SETTING	0			
WIRE SPEED-IPM		343	POTENTIOMETER SETTING 3.5		
TRAVEL SPEED-IPM		8.5			

E-33
HORIZONTAL

AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
.250" THICKNESS 5456 H-116 ALUMINUM ALLOY	3/64" DIAMETER 5356 ALUMINUM ALLOY	COVER X	CO_2	AR/CO_2 ROOT X

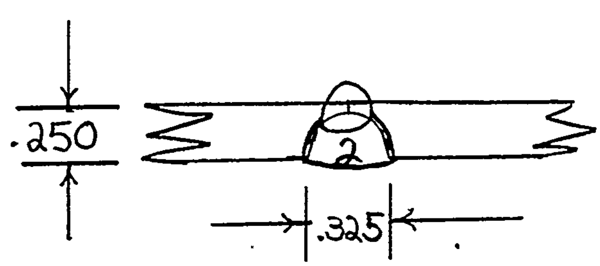
SHIELD GAS		FLOW RATE
75%HE/25%AR	X	40 CFH

"J" GROOVE

PUSHBUTTON SELECTOR SWITCHES

1	2	3	4
OUT	OUT	IN	OUT

POSITION	OVERHEAD			
WELDING VOLTAGE	14 26.2	BACKGROUND SETTING 0		
WELDING CURRENT AMPS	150 105			
REMOTE PENDANT — CURRENT SETTING	4.25 4.75	WIRE FEED PROCESS	COVER AUTO	X
			ROOT MANUAL	X
REMOTE PENDANT — VOLTAGE TRIM SETTING	0 0			
WIRE SPEED-IPM	348 282	POTENTIOMETER SETTING	ROOT 3.75	COVER AUTO
TRAVEL SPEED-IPM	20.5 13.6			



E-37

AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
			CO_2	AR/CO_2
.250" THICKNESS 5456 H-116 ALUMINUM ALLOY	3/64" DIAMETER 5356 ALUMINUM ALLOY	X		

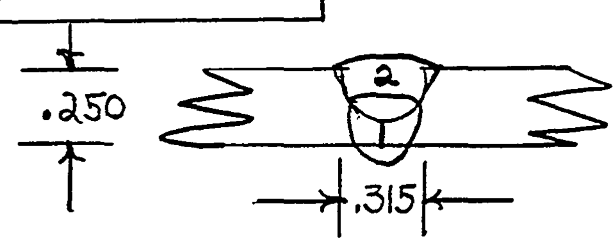
SHIELD GAS			FLOW RATE
75%HE/25%AR	X		40 CFH

"J" GROOVE

PUSHBUTTON SELECTOR SWITCHES

1	2	3	4
OUT	OUT	IN	OUT

POSITION		FLAT MECHANIZED				
WELDING VOLTAGE		24.5 26.8	BACKGROUND SETTING	0		
WELDING CURRENT AMPS		98 125				
REMOTE PENDANT	CURRENT SETTING	3.5 5.5	WIRE FEED PROCESS		AUTO	X
					MANUAL	
	VOLTAGE TRIM SETTING	0 0				
WIRE SPEED-IPM		220 300	POTENTIOMETER SETTING	AUTO		
TRAVEL SPEED-IPM		12.5 15.5				
AUTO BUG-O		D G				



E-35

AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
			CO_2	AR/CO_2
.250" THICKNESS 5083 H-321 ALUMINUM ALLOY	5556 ALUMINUM ALLOY 3/64" DIAMETER			X

SHIELD GAS		FLOW RATE
75%HE/25%AR		40 CFH

PUSHBUTTON SELECTOR SWITCHES

1	2	3	4
OUT	IN	IN	OUT

WELDING VOLTAGE		15.7	BACKGROUND SETTING		
WELDING CURRENT AMPS		130			
REMOTE PENDANT	CURRENT SETTING	5.0	WIRE FEED PROCESS	AUTO	
				MANUAL	X
	VOLTAGE TRIM SETTING	0			
WIRE SPEED-IPM		330	POTENTIOMETER SETTING	3.5	
TRAVEL SPEED-IPM		12			

F-3
VERTICAL-UP

1 PASS

AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
			CO_2	AR/CO_2
.250" THICKNESS 5083 H-321 ALUMINUM ALLOY	5556 ALUMINUM ALLOY 3/64" DIAMETER			X

SHIELD GAS		FLOW RATE
~~75%HE/25%AR~~	100% HE	100 CFH

PUSHBUTTON SELECTOR SWITCHES

1	2	3	4
OUT	IN	IN	OUT

WELDING VOLTAGE		14.5	BACKGROUND SETTING NA		
WELDING CURRENT AMPS		145			
REMOTE PENDANT	CURRENT SETTING	4.5	WIRE FEED PROCESS	AUTO	
				MANUAL	X
	VOLTAGE TRIM SETTING	0			
WIRE SPEED-IPM		333	POTENTIOMETER SETTING 3.5		
TRAVEL SPEED-IPM		10.2			

F-13
HORIZONTAL

AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
		COVER	CO_2	AR/CO_2
.250" THICKNESS 5083 H-321 ALUMINUM ALLOY	3/64" DIAMETER 5356 ALUMINUM ALLOY	X		X ROOT

SHIELD GAS		FLOW RATE
75%HE/25%AR X		40 CFH

"J" GROOVE

PUSHBUTTON SELECTOR SWITCHES

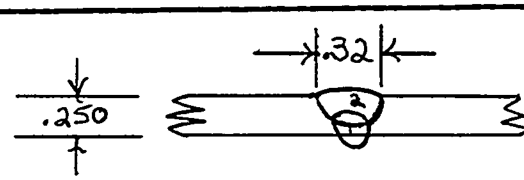
1	2	3	4
OUT	OUT	IN	OUT

POSITION	OVERHEAD				
WELDING VOLTAGE	14	25	BACKGROUND SETTING	0	0
WELDING CURRENT AMPS	158	96			

REMOTE PENDANT	CURRENT SETTING	4.5	3.5	WIRE FEED PROCESS	COVER AUTO	X
					ROOT MANUAL	X
	VOLTAGE TRIM SETTING	0	0			

WIRE SPEED-IPM	370	230	POTENTIOMETER SETTING	4	AUTO
TRAVEL SPEED-IPM	21.5	15.6			

2 PASS



AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
			CO_2	AR/CO_2
.250" THICKNESS 5083 H-321 ALUMINUM ALLOY	3/64" DIAMETER 5356 ALUMINUM ALLOY	X		

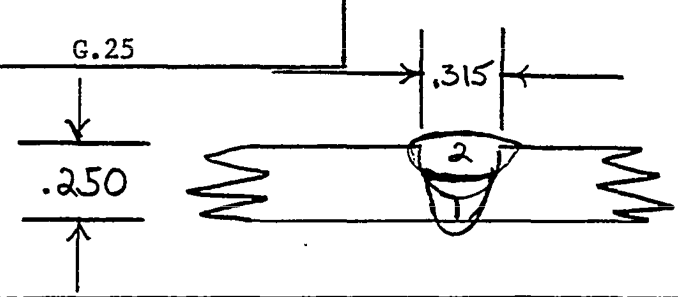
SHIELD GAS			FLOW RATE
75%HE/25%AR	X		40 CFH

"J" GROOVE

PUSHBUTTON SELECTOR SWITCHES

1	2	3	4
OUT	OUT	IN	OUT

POSITION	FLAT MECHANIZED			
WELDING VOLTAGE	24.5	26.8	BACKGROUND SETTING	0
WELDING CURRENT AMPS	98	125		
REMOTE PENDANT — CURRENT SETTING	3.5	5.5	WIRE FEED PROCESS	AUTO X / MANUAL
REMOTE PENDANT — VOLTAGE TRIM SETTING	0	0		
WIRE SPEED-IPM	220	300	POTENTIOMETER SETTING	AUTO
TRAVEL SPEED-IPM	12.5	16		
AUTO BUG-O	D	G.25		



F-29

AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
			CO_2	AR/CO_2
½" THICKNESS 5086 H-116 ALUMINUM ALLOY	3/64" DIAMETER 5356 ALUMINUM ALLOY	2 thru 6 X		X ROOT

SHIELD GAS			FLOW RATE
75%HE/25%AR	X		40 CFH

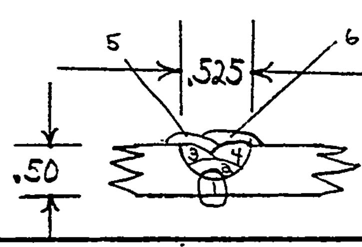
"J" GROOVE

PUSHBUTTON SELECTOR SWITCHES

1	2	3	4
OUT	OUT	IN	OUT

POSITION		VERTICAL				
WELDING VOLTAGE		17.5 26.5	26.5 26	26.5 26	BACKGROUND SETTING	0
WELDING CURRENT AMPS		145 120	130 110	120 110		
REMOTE PENDANT	CURRENT SETTING	6 5	6 4.5	5 4.5	WIRE FEED PROCESS	2-6 AUTO: X ROOT MANUAL: X
REMOTE PENDANT	VOLTAGE TRIM SETTING	1 0	0 1	0 1		
WIRE SPEED-IPM		370 290	327 272	290 272	POTENTIOMETER SETTING	ROOT 4 AUTO 2 thru 6
TRAVEL SPEED-IPM		25.5 19.1	12.9 18.3	19.1 18.3		

WELD SEQUENCE			
	1	2	3
	4	5	6



AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
		2 thru 6	CO_2	AR/CO_2
½" THICKNESS 5086 H-116 ALUMINUM ALLOY	3/64" DIAMETER 5356 ALUMINUM ALLOY	X		X ROOT

SHIELD GAS		FLOW RATE
75%HE/25%AR	100% HELIUM X	40 CFH

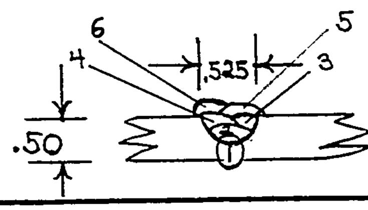
"J" GROOVE

PUSHBUTTON SELECTOR SWITCHES

1	2	3	4
OUT	OUT	IN	OUT

POSITION	HORIZONTAL					
WELDING VOLTAGE	17.8 26	27.2 28	26 28	BACKGROUND SETTING	0	
WELDING CURRENT AMPS	145 115	138 120	115 120			
REMOTE PENDANT — CURRENT SETTING	6 5	7 5	5 5	WIRE FEED PROCESS	2-6 AUTO ROOT MANUAL	X X
REMOTE PENDANT — VOLTAGE TRIM SETTING	1 0	0 2	0 2			
WIRE SPEED-IPM	412 290	367 290	290 290	POTENTIOMETER SETTING	ROOT 4.0	AUTO 2 thru 6
TRAVEL SPEED-IPM	24 17.9	15 18.7	17.9 18.7			

WELD SEQUENCE: 1 2 3
4 5 6



AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
			CO_2	AR/CO_2
5086-H116 ½" Thick ALUMINUM ALLOY	3/64" Dia. 5356 ALUMINUM ALLOY	X 2-5		X root

SHIELD GAS		FLOW RATE
75%HE/25%AR	XX	40 CFH

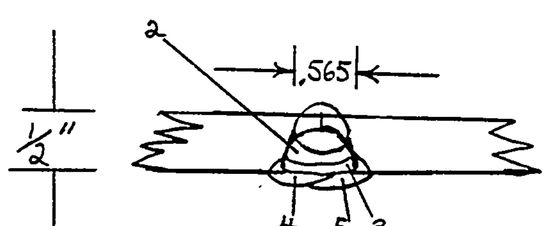
"J" Groove

PUSHBUTTON SELECTOR SWITCHES

1		2		3		4	
[redacted]	OUT	[redacted]	OUT	IN	[redacted]		OUT

POSITION	OVERHEAD				
WELDING VOLTAGE	16.1 26.1 27.4 27.2 27.2	BACKGROUND SETTING	0		
WELDING CURRENT AMPS	150 120 132 128 128				
REMOTE PENDANT: CURRENT SETTING	5.5 5.0 6.5 6 6	WIRE FEED PROCESS	2-5 AUTO	X	
			root MANUAL	X	
REMOTE PENDANT: VOLTAGE TRIM SETTING	1 00 .5 .5				
WIRE SPEED-IPM	385 290 350 325 325	POTENTIOMETER SETTING	root 4.25	2-5 Auto	
TRAVEL SPEED-IPM	21 12.7 12.9 19.1 19.1				

Weld Sequence 123
45



G-16

AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
			CO_2	AR/CO_2
5086-H116 ½" Thick ALUMINUM ALLOY	3/64" Dia. 5556 ALUMINUM ALLOY	2-5 X		root X

SHIELD GAS		FLOW RATE
75%HE/25%AR X		40 CFH

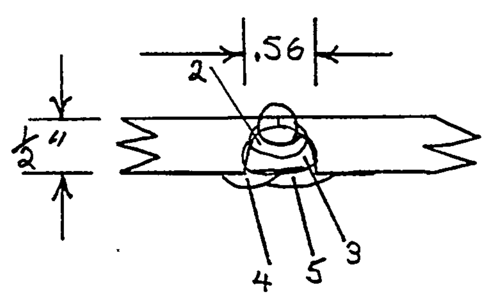
"J" Groove

PUSHBUTTON SELECTOR SWITCHES

1	2	3	4
OUT	OUT	IN	OUT

POSITION		OVERHEAD				
WELDING VOLTAGE		16.5 26.8 27.2 27.2 28	BACKGROUND SETTING	0		
WELDING CURRENT AMPS		145 132 125 128 130				
REMOTE PENDANT	CURRENT SETTING	5.5 6.0 6.0 6.0 6.0	WIRE FEED PROCESS		2-5 AUTO	X
					root MANUAL	X
	VOLTAGE TRIM SETTING	1 0 0 .5 1				
WIRE SPEED-IPM		375 325 325 325 325	POTENTIOMETER SETTING	root 4.25	2-5 Auto	
TRAVEL SPEED-IPM		24 14.7 12.9 19.1 19.1				

Weld Sequence 1 2 3
4 5



G-17

AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
			CO_2	AR/CO_2
.50" THICKNESS 5086 H-116 ALUMINUM ALLOY	5356 ALUMINUM ALLOY 3/64" DIAMETER	X		

"J" GROOVE

SHIELD GAS			FLOW RATE
75%HE/25%AR	X		40 CFH

PUSHBUTTON SELECTOR SWITCHES

1	2	3	4
OUT	IN	IN	OUT

POSITION	FLAT

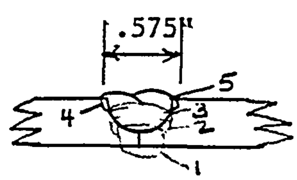
WELDING VOLTAGE	1 22	2 26	3 27.2	4 26.2	5 27.5	BACKGROUND SETTING	5.0

WELDING CURRENT AMPS	1 122	2 152	3 165	4 155	5 165

REMOTE PENDANT	CURRENT SETTING	1 4	2 5.5	3 6	4 5.5	5 6	WIRE FEED PROCESS	AUTO	
								MANUAL	X
	VOLTAGE TRIM SETTING	1 0	2 2	3 2	4 2	5 2			

WIRE SPEED-IPM	1 300	2 320	3 408	4 368	5 402	POTENTIOMETER SETTING	1 3.25	2 4	3 4.5	4 4	5 4.5

TRAVEL SPEED-IPM	1 24.7	2 16.8	3 16.8	4 22.1	5 19.1



AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
½" THICKNESS 5456 H-116 ALUMINUM ALLOY	3/64" DIAMETER 5356 ALUMINUM ALLOY	2-5 X	CO_2	AR/CO_2 ROOT X

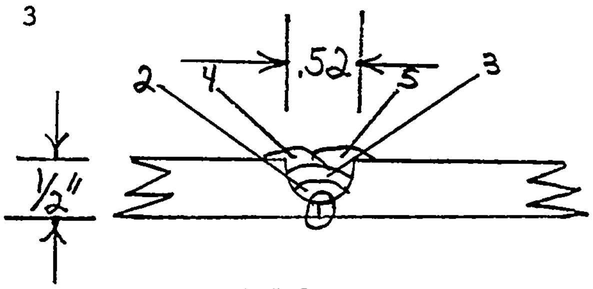
SHIELD GAS		FLOW RATE
75%HE/25%AR	X	40 CFH

"J" GROOVE

PUSHBUTTON SELECTOR SWITCHES

1	2	3	4
OUT	IN	OUT	OUT

POSITION		VERTICAL				
WELDING VOLTAGE		17.5 25 26.8 27.1 27.1	BACKGROUND SETTING 0			
WELDING CURRENT AMPS		145 125 130 122 122				
REMOTE PENDANT	CURRENT SETTING	6 5 6 5 5	WIRE FEED PROCESS		2-5 AUTO	X
					ROOT MANUAL	X
	VOLTAGE TRIM SETTING	1 0 0 1 1				
WIRE SPEED-IPM		370 290 335 292 292	POTENTIOMETER SETTING	ROOT 4	2-5 AUTO	
TRAVEL SPEED-IPM		24 11.2 12 14.2 15.9				
WELD SEQUENCE		1 2 3 4 5				



H-5

AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
			CO_2	AR/CO_2
½" THICKNESS 5456 H-116 ALUMINUM ALLOY	3/64" DIAMETER 5356 ALUMINUM ALLOY	2-6 X		X ROOT

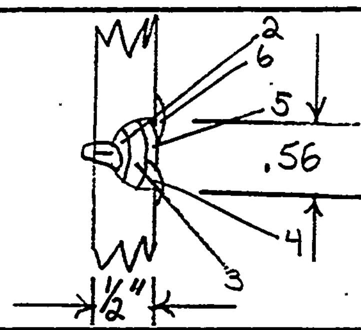
SHIELD GAS			FLOW RATE
75%HE/25%AR	100% HE	X	40 CFH

"J" GROOVE

PUSHBUTTON SELECTOR SWITCHES

1	2	3	4
OUT	IN	OUT	OUT

POSITION	HORIZONTAL		
WELDING VOLTAGE	16 26 29 26.8 26.8 27	BACKGROUND SETTING	0
WELDING CURRENT AMPS	135 118 135 130 130 125		
REMOTE PENDANT — CURRENT SETTING	6 5 7 5.5 5.5 5.5	WIRE FEED PROCESS	2-6 AUTO X ROOT MANUAL X
REMOTE PENDANT — VOLTAGE TRIM SETTING	1 0 1 1 1 1		
WIRE SPEED-IPM	380 290 372 312 312 312	POTENTIOMETER SETTING	ROOT 4 2-6 AUTO
TRAVEL SPEED-IPM	20.5 19.1 13.5 16.8 14.2 26.3		
WELD SEQUENCE	1 2 3 4 5 6		



H-1

AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
			CO_2	AR/CO_2
½" THICKNESS 5456 H-116 ALUMINUM ALLOY	3/64" DIAMETER 5356 ALUMINUM ALLOY	2-5 X		ROOT X

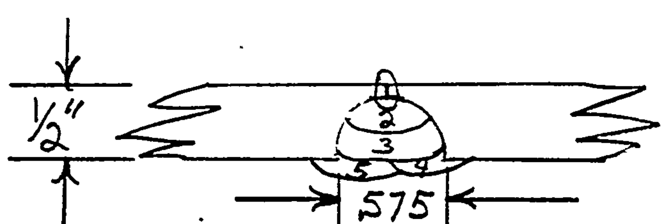
SHIELD GAS			FLOW RATE
75%HE/25%AR	X		40 CFH

"J" GROOVE

PUSHBUTTON SELECTOR SWITCHES

1	2	3	4
OUT	IN	OUT	OUT

POSITION	OVERHEAD		
WELDING VOLTAGE	16 25 27 27.2 27.2	BACKGROUND SETTING	0
WELDING CURRENT AMPS	150 125 125 132 132		
REMOTE PENDANT — CURRENT SETTING	5 5 6 6 6	WIRE FEED PROCESS	2-5 AUTO X ROOT MANUAL X
REMOTE PENDANT — VOLTAGE TRIM SETTING	1 0 .5 1 1		
WIRE SPEED-IPM	390 290 330 314 314	POTENTIOMETER SETTING	ROOT 4.25 2-5 AUTO
TRAVEL SPEED-IPM	20 12.4 12.2 16.2 16.2		
WELD SEQUENCE	1 2 3 4 5		



H-4

AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC CO_2	SHORT ARC AR/CO_2
½" THICKNESS 5456 H-116 ALUMINUM ALLOY	3/64" DIAMETER 5356 ALUMINUM ALLOY	X		

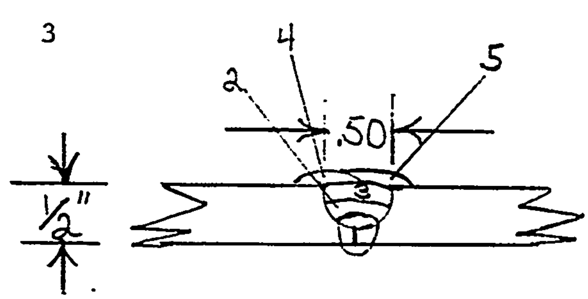
SHIELD GAS		FLOW RATE
75%HE/25%AR	X	40 CFH

"J" GROOVE

PUSHBUTTON SELECTOR SWITCHES

1	2	3	4
OUT	IN	OUT	OUT

POSITION	FLAT MECHANIZED						
WELDING VOLTAGE	25.2	27	29	BACKGROUND SETTING	5	5	5
	27.5	27.5			5	5	
WELDING CURRENT AMPS	147	140	148				
	122	122					
REMOTE PENDANT CURRENT SETTING	4	6.5	7.5	WIRE FEED PROCESS	AUTO		
	6	6			MANUAL	X	
REMOTE PENDANT VOLTAGE TRIM SETTING	0						
WIRE SPEED-IPM	358	370	370	POTENTIOMETER SETTING	4	4	4
	300	300			3.25	3.25	
TRAVEL SPEED-IPM	19.5	12.5	12.5	BUG-O SETTINGS	J .5	D	D
	17.2	17.2			H	H	
WELD SEQUENCE	1	2	3				
	4	5					



H-6

AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
			CO_2	AR/CO_2
½" THICKNESS 5083 H-321 ALUMINUM ALLOY	3/64" DIAMETER 5356 ALUMINUM ALLOY	2-6 X		X ROOT

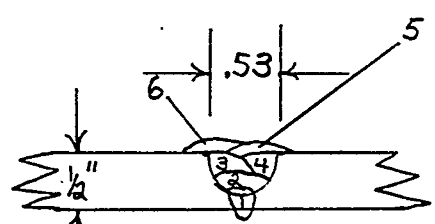
SHIELD GAS			FLOW RATE
75%HE/25%AR	X		40 CFH

"J" GROOVE

PUSHBUTTON SELECTOR SWITCHES

1	2	3	4
OUT	IN	OUT	OUT

POSITION		VERTICAL-UP					
WELDING VOLTAGE		17 26 26 26 25.8 25.8			BACKGROUND SETTING	0	
WELDING CURRENT AMPS		140 130 118 118 112 110					
REMOTE PENDANT	CURRENT SETTING	6 6 5 5 4.5 4.5			WIRE FEED PROCESS	2-6 AUTO	X
						ROOT MANUAL	X
	VOLTAGE TRIM SETTING	1 0 0 0 .5 0					
WIRE SPEED-IPM		372 325 290 290 275 275			POTENTIOMETER SETTING	ROOT 4.0	2-6 AUTO
TRAVEL SPEED-IPM		22.1 11.8 16.8 19.1 15.8 16.5					
WELD SEQUENCE		1 2 3 4 5 6					



I-17

AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
			CO_2	AR/CO_2
½" THICKNESS 5083 H-321 ALUMINUM ALLOY	3/64" DIAMETER 5356 ALUMINUM ALLOY	2-6 X		X ROOT

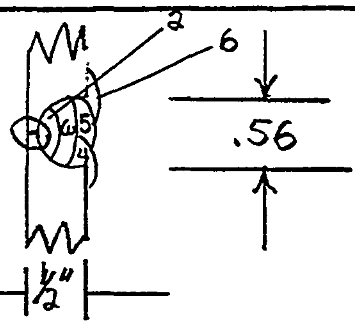
SHIELD GAS			FLOW RATE
75%HE/25%AR	100% HE	X	40 CFH

"J" GROOVE

PUSHBUTTON SELECTOR SWITCHES

1	2	3	4
OUT	IN	OUT	OUT

POSITION		HORIZONTAL			
WELDING VOLTAGE		16.2 25.8 28.2 27.5 27.8 27.8	BACKGROUND SETTING 0		
WELDING CURRENT AMPS		138 120 138 135 133 134			
REMOTE PENDANT	CURRENT SETTING	6 5 7 6 6 6	WIRE FEED PROCESS	2-6 AUTO	X
				ROOT MANUAL	X
	VOLTAGE TRIM SETTING	1 0 0 1 1 1			
WIRE SPEED-IPM		380 295 372 332 332 332	POTENTIOMETER SETTING	ROOT 4	2-6 AUTO
TRAVEL SPEED-IPM		20.5 19.1 13.1 17 12.9 26.3			
WELD SEQUENCE		1 2 3 4 5 6			



I-21

AIRCO PA-350 MACHINE SETTING

BASE MATERIAL	WIRE TYPE & DIAMETER	PROCESS SELECTOR		
		PULSE	SHORT ARC	
			CO_2	AR/CO_2
½" THICKNESS 5083 H-321 ALUMINUM ALLOY	3/64" DIAMETER 5356 ALUMINUM ALLOY	2-6 X		X ROOT

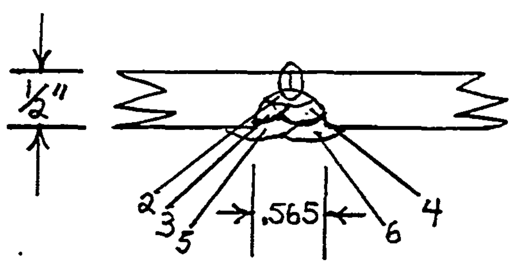
SHIELD GAS			FLOW RATE
75%HE/25%AR	X		40 CFH

"J" GROOVE

PUSHBUTTON SELECTOR SWITCHES

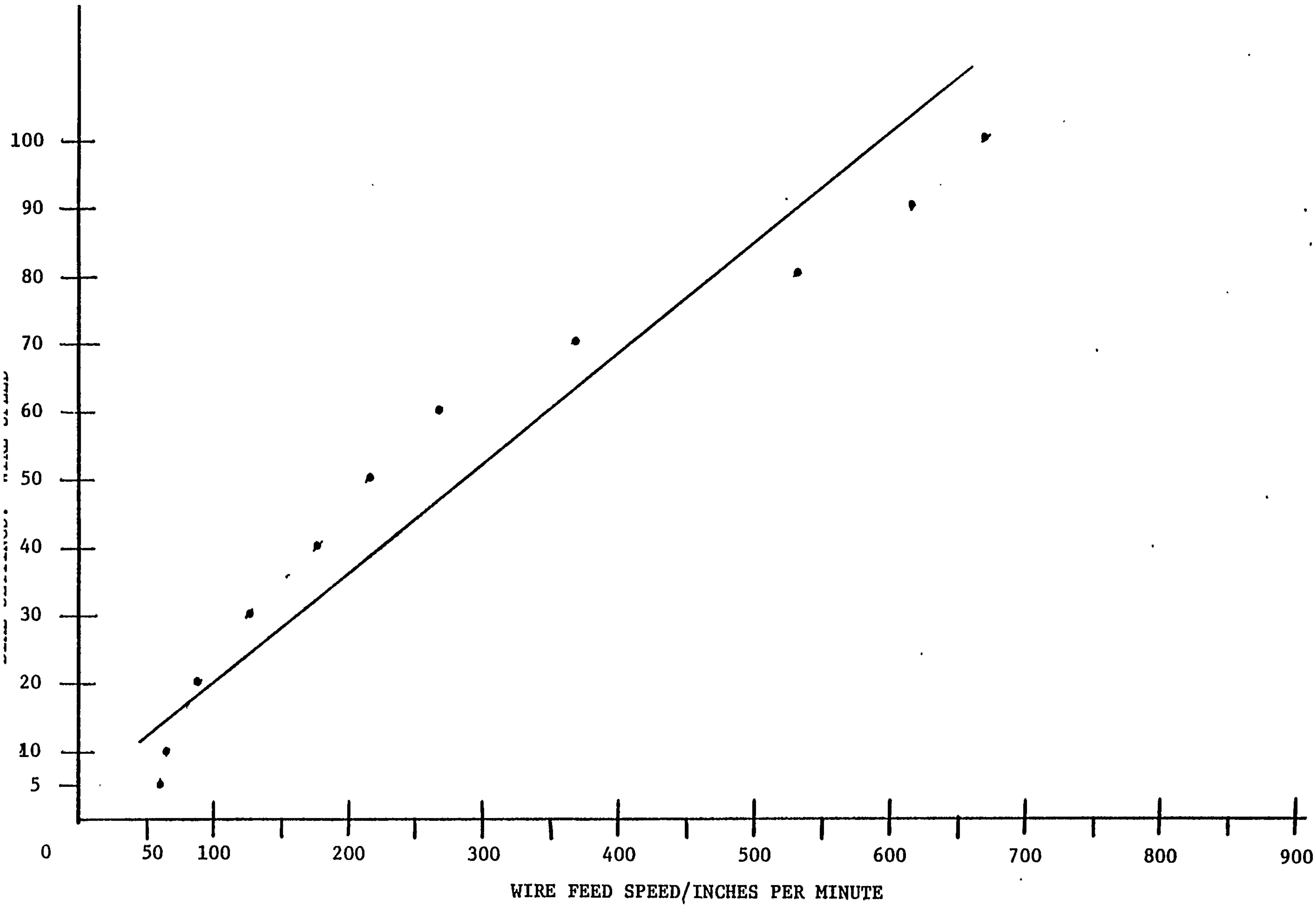
1		2		3		4	
	OUT	IN			OUT		OUT

POSITION		OVERHEAD				
WELDING VOLTAGE		15.8 26	26.5 26.5	26 26.5	BACKGROUND SETTING	0
WELDING CURRENT AMPS		145 118	132 105	118 105		
REMOTE PENDANT	CURRENT SETTING	5 5	6 4.5	5 4.5	WIRE FEED PROCESS	2-6 AUTO X ROOT MANUAL X
	VOLTAGE TRIM SETTING	1 0	0 1	0 1		
WIRE SPEED-IPM		390 290	328 275	290 275	POTENTIOMETER SETTING	ROOT 4.25 2-6 AUTO
TRAVEL SPEED-IPM		21 17.6	12.6 13.9	17.6 13.9		
WELD SEQUENCE		1 4	2 5	3 6		



I-16

AIRCO PA-350 MACHINE SETTING



WIRE FEED SPEED VS. DIAL SETTINGS
3/64" DIAMETER 5556 ALUMINUM ALLOY FILLER WIRE
GILLILAND MTG 4001 FEEDER; MTG 2000 GUN

BASE MATERIAL ALLOY

FILLER WIRE ALLOY

			VERTICAL-UP				HORIZONTAL				OVERHEAD				FLAT			
			030	.035	3/64	1/16	030	.035	3/64	1/16	030	.035	3/64	1/16	030	.035	3/64	1/16
A	.063" 5086 H-32	5356			XX												XX	
		5556																
B	.100" 5086 H-32	5356															XX	
		5556		XX[3]														
C	.125" 5083 H-323	5356															XX	
		5556		XX[2]				XX										
D	.250" 5086 H-116	5356																
		5556																
E	.250" 5456 H-116	5356																
		5556																
F	.250" 5083 H-321	5356																
		5556																
G	.500" 5086 H-116	5356															XX	
		5556																
H	.500" 5456 H-116	5356																
		5556																
I	.500" 5083 H-321	5356															XX	
		5556																

FILLER WIRE DIAMETER (INCH)

GILLILAND MACHINE SETTING MATRIX

BASE MATERIAL	WIRE TYPE & DIAMETER	PULSE PROCESS SELECTOR	
		120	60
.063" THICKNESS 5086 H-32 ALUMINUM ALLOY	5356 ALUM. ALLOY .045" DIAMETER		X

SHIELD GAS			FLOW RATE
75%HE/25%AR	X		40 CFH

SELECTOR SWITCHES	
EXTRA LOW	NORMAL
☐ ☐ ☐	STABILIZER - LOW ENERGIZER - OFF

WELDING VOLTAGE	9.8		
WELDING CURRENT AMPS	42		
POSITION	VERTICAL-UP		
VOLTAGE SETTING	BACKGROUND 2.0	PEAK 4.75	
WIRE SPEED-IPM	110	POTENTIOMETER SETTING	24
TRAVEL SPEED-IPM	19		

MTG - 2000 - FEEDER
MTG - 4001 - AIR-COOLED GUN
400 AMP..

MACHINE SETTINGS FOR
GILLILAND CV 600 FI-PA

BASE MATERIAL	WIRE TYPE & DIAMETER	PULSE PROCESS SELECTOR	
		120	60
.063" THICKNESS 5086 H-32 ALUMINUM ALLOY	3/64" DIAMETER 5356 ALUMINUM ALLOY		X

SHIELD GAS		FLOW RATE
75%HE/25%AR	X	40 CFH

SELECTOR SWITCHES

EXTRA LOW	NORMAL
☐ ☐ ☐	STABILIZER - LOW ENERGIZER - OFF

WELDING VOLTAGE	13.5	
WELDING CURRENT AMPS	50	
POSITION	MECHANIZED FLAT	
VOLTAGE SETTING	BACKGROUND 3.5	PEAK 4.25
WIRE SPEED-IPM	130	POTENTIOMETER SETTING 31
TRAVEL SPEED-IPM	24.5	

AUTO BUG-O	L.75

MTG - 2000 - FEEDER
MTG - 4001 - AIR-COOLED GUN
400 AMP.

A1.34

MACHINE SETTINGS FOR
GILLILAND CV 600 FI-PA

BASE MATERIAL	WIRE TYPE & DIAMETER	PULSE PROCESS SELECTOR	
		120	60
.100" THICKNESS 5086 H-32 ALUMINUM ALLOY	5556 ALUM. ALLOY .035" DIAMETER		X

SHIELD GAS			FLOW RATE
75%HE/25%AR	X		40 CFH

SELECTOR SWITCHES	
EXTRA LOW	NORMAL
☐ ☐ ☐	STABILITY - HIGH ENERGIZER - OFF

WELDING VOLTAGE	15	
WELDING CURRENT AMPS	50	
POSITION	VERTICAL-UP	
VOLTAGE SETTING	BACKGROUND 3.5	PEAK 6.0
WIRE SPEED-IPM	245	POTENTIOMETER SETTING 55
TRAVEL SPEED-IPM	15.8	

MTG - 2000 - FEEDER
MTG - 4001 - AIR-COOLED GUN

MACHINE SETTINGS FOR
GILLILAND CV 600 FI-FA

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<tr><td>BASE
MATERIAL</td><td>WIRE TYPE &
DIAMETER</td><td colspan="2">PULSE
PROCESS SELECTOR</td></tr>
<tr><td rowspan="2">.100" THICKNESS
5086 H-32
ALUMINUM ALLOY</td><td rowspan="2">5556 ALUM. ALLOY
.035" DIAMETER</td><td>120</td><td>60</td></tr>
<tr><td></td><td>X</td></tr>
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SHIELD GAS			FLOW RATE
75%HE/25%AR	X		40 CFH

SELECTOR SWITCHES	
EXTRA LOW	NORMAL
☐ ☐ ☐	ENERGIZER - OFF STABILIZER - HIGH

<table>
<tr><td>WELDING
VOLTAGE</td><td colspan="2">16.9</td></tr>
<tr><td>WELDING
CURRENT
AMPS</td><td colspan="2">56</td></tr>
<tr><td>POSITION</td><td colspan="2">VERTICAL-UP</td></tr>
<tr><td>VOLTAGE
SETTING</td><td>BACKGROUND
4.0</td><td>PEAK
5.25</td></tr>
<tr><td>WIRE
SPEED-IPM</td><td>245</td><td>POTENTIOMETER
SETTING 55</td></tr>
<tr><td>TRAVEL
SPEED-IPM</td><td colspan="2">18</td></tr>
<tr><td colspan="3">MTG - 2000 - FEEDER
MTG - 4001 - AIR-COOLED GUN
400 AMP.</td></tr>
</table>

MACHINE SETTINGS FOR
GILLILAND CV 600 FI-PA

BASE MATERIAL	WIRE TYPE & DIAMETER	PULSE PROCESS SELECTOR	
		120	60
.100" THICKNESS 5086 H-32 ALUMINUM ALLOY	5556 ALUM. ALLOY .035 " DIAMETER		X

SHIELD GAS			FLOW RATE
75%HE/25%AR	X		40 CFH

SELECTOR SWITCHES	
EXTRA LOW	NORMAL
☐ ☐ ☐	ENERGIZER - OFF STABILIZER - HIGH

WELDING VOLTAGE	18.8		
WELDING CURRENT AMPS	53		
POSITION	VERTICAL-UP		
VOLTAGE SETTING	BACKGROUND 4.35-4.5	PEAK 4.8-5.0	
WIRE SPEED-IPM	245	POTENTIOMETER SETTING	55
TRAVEL SPEED-IPM	18.3		

MTG - 2000 - FEEDER
MTG - 4001 - AIR-COOLED GUN
400 AMP.

MACHINE SETTINGS FOR
GILLILAND CV 600 FI-PA

BASE MATERIAL	WIRE TYPE & DIAMETER	PULSE PROCESS SELECTOR	
		120	60
.100" THICKNESS 5086 H-32 ALUMINUM ALLOY	3/64" DIAMETER 5356 ALUMINUM ALLOY		X

SHIELD GAS		FLOW RATE
75%HE/25%AR	X	40 CFH

SELECTOR SWITCHES	
EXTRA LOW	NORMAL
☐ ☐ ☐	STABILIZER - LOW ENERGIZER - OFF

WELDING VOLTAGE	16.5	
WELDING CURRENT AMPS	60	
POSITION	MECHANIZED FLAT	
VOLTAGE SETTING	BACKGROUND 4.0	PEAK 6.5
WIRE SPEED-IPM	150	POTENTIOMETER SETTING 38
TRAVEL SPEED-IPM	22	

AUTO BUG-O	K.25

MTG - 2000 - FEEDER
MTG - 4001 - AIR-COOLED GUN
400 AMP.

B.77

MACHINE SETTINGS FOR
GILLILAND CV 600 FI-PA

BASE MATERIAL	WIRE TYPE & DIAMETER	PULSE PROCESS SELECTOR	
		120	60
.125" THICKNESS 5083 H-323 ALUMINUM ALLOY	5556 ALUM. ALLOY .035 DIAMETER		X

SHIELD GAS			FLOW RATE
75%HE/25%AR	X		40 CFH

SELECTOR SWITCHES	
EXTRA LOW	NORMAL
☐ ☐ ☐	STABILIZER - HIGH ENERGIZER - OFF

WELDING VOLTAGE	20.2		
WELDING CURRENT AMPS	68		
POSITION	VERTICAL-UP		
VOLTAGE SETTING	BACKGROUND 4.75	PEAK 5.5	
WIRE SPEED-IPM	350	POTENTIOMETER SETTING 65	
TRAVEL SPEED-IPM	15.8		

MTG - 2000 - FEEDER
MTG - 4001 - AIR-COOLED GUN
400 AMP.

MACHINE SETTINGS FOR
GILLILAND CV 600 FI-PA

BASE MATERIAL	WIRE TYPE & DIAMETER	PULSE PROCESS SELECTOR	
		120	60
.125" THICKNESS 5083 H-323 ALUMINUM ALLOY	5556 ALUM. ALLOY .035" DIAMETER		X

SHIELD GAS			FLOW RATE
75%HE/25%AR	X		40 CFH

SELECTOR SWITCHES	
EXTRA LOW	NORMAL
☐ ☐ ☐	STABILIZER - HIGH ENERGIZER - OFF

WELDING VOLTAGE	21.7		
WELDING CURRENT AMPS	68		
POSITION	VERTICAL-UP		
VOLTAGE SETTING	BACKGROUND 5.0		PEAK 6.0
WIRE SPEED-IPM	350	POTENTIOMETER SETTING 65	
TRAVEL SPEED-IPM	18.4		

MTG - 2000 - FEEDER
MTG - 4001 - AIR-COOLED GUN
400 AMP.

MACHINE SETTINGS FOR
GILLILAND CV 600 FI-PA

BASE MATERIAL	WIRE TYPE & DIAMETER	PULSE PROCESS SELECTOR	
		120	60
.125" THICKNESS 5083 H-323 ALUMINUM ALLOY	5556 ALUM. ALLOY .035" DIAMETER		X

SHIELD GAS			FLOW RATE
75%HE/25%AR	X		40 CFH

SELECTOR SWITCHES	
EXTRA LOW	NORMAL STABILIZER - HIGH ENERGIZER - OFF

WELDING VOLTAGE	20.5	
WELDING CURRENT AMPS	65	
POSITION	HORIZONTAL	
VOLTAGE SETTING	BACKGROUND 4.75-5	PEAK 5.5
WIRE SPEED-IPM	350	POTENTIOMETER SETTING 65
TRAVEL SPEED-IPM	18	

MTG - 2000 - FEEDER
MTG - 4001 - AIR-COOLED GUN
400 AMP.

MACHINE SETTINGS FOR
GILLILAND CV 600 FI-PA

BASE MATERIAL	WIRE TYPE & DIAMETER	PULSE PROCESS SELECTOR	
		120	60
.125" THICKNESS 5083 H-323 ALUMINUM ALLOY	3/64" DIAMETER 5356 ALUMINUM ALLOY		X

SHIELD GAS			FLOW RATE
75%HE/25%AR	X		40 CFH

SELECTOR SWITCHES	
EXTRA LOW	NORMAL
☐ ☐ ☐	ENERGIZER - OFF STABILIZER- LOW

WELDING VOLTAGE	18.6	
WELDING CURRENT AMPS	68	
POSITION	MECHANIZED FLAT	
VOLTAGE SETTING	BACKGROUND 4.5	PEAK 6.75
WIRE SPEED-IPM	175	POTENTIOMETER SETTING 39
TRAVEL SPEED-IPM	16.2	

MTG - 2000 - FEEDER
MTG - 4001 - AIR-COOLED GUN
400 AMP.

AUTO BUG-O: G

C.67

MACHINE SETTINGS FOR
GILLILAND CV 600 FI-PA

BASE MATERIAL	WIRE TYPE & DIAMETER	PULSE PROCESS SELECTOR 120	60
.5" THICKNESS 5086 H-116 ALUMINUM ALLOY	3/64" DIAMETER 5356 ALUMINUM ALLOY	X	

"J" GROOVE

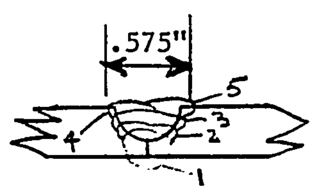
SHIELD GAS			FLOW RATE
75%HE/25%AR	X		40 CFH

SELECTOR SWITCHES

EXTRA LOW	NORMAL
☐ ☐ ☐	ENERGIZER - LOW STABILIZER - OFF

	1	2	3	4	5
WELDING VOLTAGE	21.3	25.8	27.3	23	23
WELDING CURRENT AMPS	120	155	176	116	117
POSITION	FLAT				
VOLTAGE SETTING BACKGROUND	5	5.5	6	5.25	5.25
VOLTAGE SETTING PEAK	5.5	6.25	7	6.5	6.5
WIRE SPEED-IPM	270	370	475	270	265
POTENTIOMETER SETTING	60	70	75	60	58
TRAVEL SPEED-IPM	16.2	12.7	15	15.6	16.2

MTG - 2000 - FEEDER
MTG - 4001 - AIR-COOLED GUN
400 AMP.
5 PASS WELD



MACHINE SETTINGS FOR
GILLILAND CV 600 FI-PA

BASE MATERIAL	WIRE TYPE & DIAMETER	PULSE PROCESS SELECTOR	
		120	60
.5" THICKNESS 5083 H-321 ALUMINUM ALLOY	3/64" DIAMETER 5356 ALUMINUM ALLOY	X	

"J" GROOVE

SHIELD GAS			FLOW RATE
75%HE/25%AR	X		40 CFH

SELECTOR SWITCHES

EXTRA LOW	NORMAL
☐ ☐ ☐	STABILIZER - LOW ENERGIZER - OFF

	1	2	3	4
WELDING VOLTAGE	24.5	29.8	30.2	30.4
WELDING CURRENT AMPS	154	180	148	152

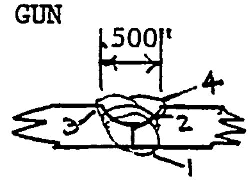
POSITION	FLAT

	BACKGROUND 1	2	3	4	PEAK 1	2	3	4
VOLTAGE SETTING	5.5	6.25	6.5	6.5	7	7.25	7	7.25

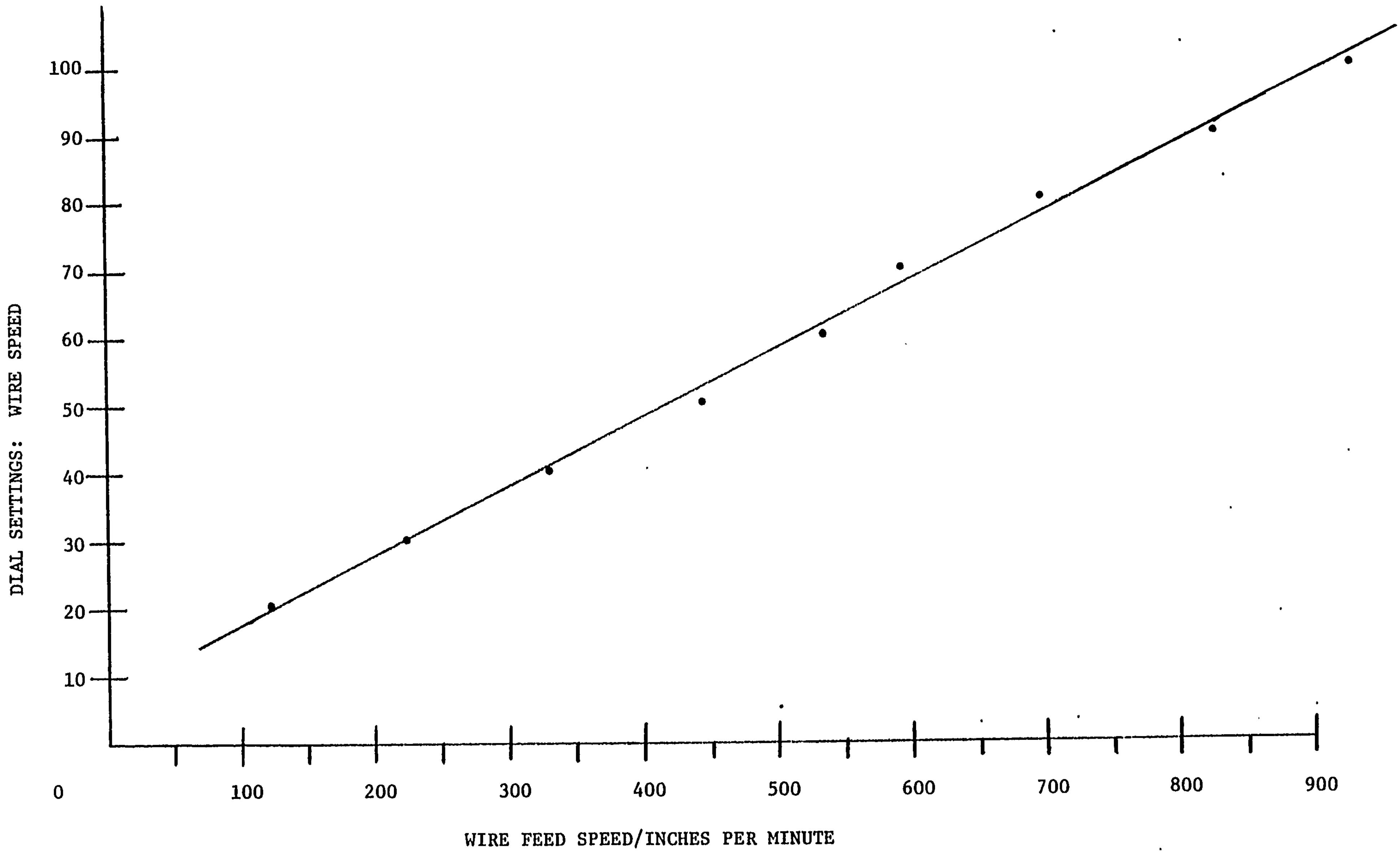
	1	2	3	4	POTENTIOMETER SETTING 1	2	3	4
WIRE SPEED-IPM	330	475	300	300	68	75	65	65

	1	2	3	4
TRAVEL SPEED-IPM	16.8	13.1	21	18.3

MTG - 2000 - FEEDER
MTG - 4001 - AIR-COOLED GUN
400 AMP.
4 PASS WELD



MACHINE SETTINGS FOR
GILLILAND CV 600 FI-PA



WIRE FEED SPEED VS. DIAL SETTINGS
.045" DIAMETER 5556 ALUMINUM ALLOY FILLER WIRE
M & K FEEDER

BASE MATERIAL ALLOY	FILLER WIRE ALLOY	VERTICAL-UP				HORIZONTAL				OVERHEAD				FLAT			
		030	.035	3/64	1/16	030	.035	3/64	1/16	030	.035	3/64	1/16	030	.035	3/64	1/16
A .063" 5086 H-32	5356		XX														
	5556																
B .100" 5086 H-32	5356		XX														
	5556																
C .125" 5083 H-323	5356		XX[2]														
	5556															XX	
D .250" 5086 H-116	5356																
	5556															XX	
E .250" 5456 H-116	5356																
	5556																
F .250" 5083 H-321	5356																
	5556															XX	
G .500" 5086 H-116	5356																
	5556																
H .500" 5456 H-116	5356																
	5556																
I .500" 5083 H-321	5356															XX[2]	
	5556																

FILLER WIRE DIAMETER
(INCH)

MILLER MACHINE SETTING MATRIX

BASE MATERIAL	WIRE TYPE & DIAMETER	PULSE PROCESS SELECTOR	
		120	60
.063" THICK 5086 H-32 ALUMINUM ALLOY	.035" DIAMETER 5356 ALUMINUM ALLOY		X

SHIELD GAS			FLOW RATE
75%HE/25%AR	X		40 CFH

SELECTOR SWITCHES	
ARC SUSTAINER	HIGH ☐
	LOW ■

POSITION	VERTICAL-UP
WELDING VOLTAGE	18.7
WELDING CURRENT AMPS	39
PEAK CURRENT SETTING	225
BACK VOLTAGE SETTING	13
WIRE SPEED-IPM	170
TRAVEL SPEED-IPM	17.1
POTENTIOMETER SETTING WIRE SPEED	.60 TEN TURN

AIRCO AHF-NP-AH 35-C2

MACHINE SETTINGS FOR
MILLER PULSTAR 450

BASE MATERIAL	WIRE TYPE & DIAMETER	PULSE PROCESS SELECTOR	
		120	60
.100" THICK 5086 H-32 ALUMINUM ALLOY	.035" DIAMETER 5356 ALUMINUM ALLOY		X

SHIELD GAS			FLOW RATE
75%HE/25%AR	X		40 CFH

SELECTOR SWITCHES

ARC SUSTAINER HIGH ☐

LOW ■

POSITION	VERTICAL-UP
WELDING VOLTAGE	20.4
WELDING CURRENT AMPS	58
PEAK CURRENT SETTING	250
BACK VOLTAGE SETTING	16
WIRE SPEED-IPM	244
TRAVEL SPEED-IPM	17.1
POTENTIOMETER SETTING WIRE SPEED	1.25 TEN TURN

AIRCO AHF-NP-AH 35-C2

MACHINE SETTINGS FOR
MILLER PULSTAR 450

BASE MATERIAL	WIRE TYPE & DIAMETER	PULSE PROCESS SELECTOR	
		120	60
.125" THICK 5083 H-323 ALUMINUM ALLOY	.035" DIAMETER 5356 ALUMINUM ALLOY		X

SHIELD GAS			FLOW RATE
75%HE/25%AR	X		40 CFH

SELECTOR SWITCHES

ARC SUSTAINER HIGH ☐

LOW ■

POSITION	VERTICAL-UP
WELDING VOLTAGE	23.0
WELDING CURRENT AMPS	75
PEAK CURRENT SETTING	250
BACK VOLTAGE SETTING	21
WIRE SPEED-IPM	320
TRAVEL SPEED-IPM	20.5
POTENTIOMETER SETTING WIRE SPEED	2.0 TEN TURN

AIRCO AHF-NP-AH 35-C2

MACHINE SETTINGS FOR
MILLER PULSTAR 450

BASE MATERIAL	WIRE TYPE & DIAMETER	PULSE PROCESS SELECTOR 120	60
.125" THICK 5083 H-323 ALUMINUM ALLOY	.035" DIAMETER 5356 ALUMINUM		X

SHIELD GAS			FLOW RATE
75%HE/25%AR	X		40 CFH

SELECTOR SWITCHES		
ARC SUSTAINER	HIGH	☐
	LOW	■

POSITION	VERTICAL-UP
WELDING VOLTAGE	21.8
WELDING CURRENT AMPS	63
PEAK CURRENT SETTING	300
BACK VOLTAGE SETTING	18
WIRE SPEED-IPM	270
TRAVEL SPEED-IPM	17.1
POTENTIOMETER SETTING WIRE SPEED	340

M & K COBRAMATIC

MACHINE SETTINGS FOR
MILLER PULSTAR 450

<table>
<tr><td>BASE MATERIAL</td><td>WIRE TYPE & DIAMETER</td><td colspan="2">PULSE PROCESS SELECTOR</td></tr>
<tr><td rowspan="2">.125" THICKNESS
5083 H-323
ALUMINUM ALLOY</td><td rowspan="2">5556 ALUMINUM ALLOY
3/64" DIAMETER</td><td>120</td><td>60</td></tr>
<tr><td></td><td>X</td></tr>
</table>

<table>
<tr><td colspan="3">SHIELD GAS</td><td>FLOW RATE</td></tr>
<tr><td>75%HE/25%AR</td><td>X</td><td></td><td>40 CFH</td></tr>
</table>

SELECTOR SWITCHES

ARC SUSTAINER HIGH ☒

LOW ☐

POSITION	MECHANIZED FLAT
WELDING VOLTAGE	21.2
WELDING CURRENT AMPS	70
PEAK CURRENT SETTING	250
BACK VOLTAGE SETTING	17
WIRE SPEED-IPM	170
TRAVEL SPEED-IPM	16.1
POTENTIOMETER SETTING	.70

AUTO BUG-O	G

C.68. AIRCO AHF-NP-AH 35-C2
C.69
C.70

MACHINE SETTINGS FOR
MILLER PULSTAR 450

BASE MATERIAL	WIRE TYPE & DIAMETER	PULSE PROCESS SELECTOR	
		120	60
5086 H-116 .250" THICKNESS ALUMINUM ALLOY	3/64" DIAMETER 5556 ALUMINUM ALLOY	X	

SHIELD GAS			FLOW RATE
75%HE/25%AR	X		40 CFH

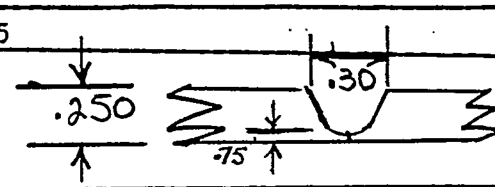
"J" GROOVE

SELECTOR SWITCHES

ARC SUSTAINER HIGH ■

LOW □

POSITION	FLAT MECHANIZED			
WELDING VOLTAGE	23	24		
WELDING CURRENT AMPS	105	105		
PEAK CURRENT SETTING	325	325		
BACK VOLTAGE SETTING	16	16		
WIRE SPEED-IPM	355	380		
TRAVEL SPEED-IPM	16	12.2		
POTENTIOMETER SETTING WIRE SPEED	1.55	1.7	TEN TURN	
AUTO BUG-O	G.5	C.5		



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MACHINE SETTINGS FOR
MILLER PULSTAR 450

BASE MATERIAL	WIRE TYPE & DIAMETER	PULSE PROCESS SELECTOR	
		120	60
5083-H 321 .250 Thick ALU Alloy	3/64" Dia. 5556 ALU Alloy	XX	

SHIELD GAS		FLOW RATE
75%HE/25%AR X		40 CFH

"J" Groove

SELECTOR SWITCHES

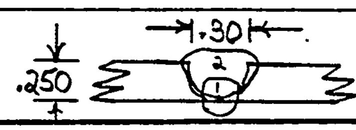
ARC SUSTAINER HIGH X☒

LOW ☐

POSITION	Mechanized Flat	
WELDING VOLTAGE	22.2	23
WELDING CURRENT AMPS	98	118
CURRENT SETTING	300	350
VOLTAGE SETTING	16	16
WIRE SPEED-IPM	230	265
TRAVEL SPEED-IPM	12	16
POTENTIOMETER SETTING	1.5	1.8
AUTO BUG-O	C.5	G

AIRCO AHF-NP-AH 35-C2

F-26



MACHINE SETTINGS FOR
MILLER PULSTAR 450

BASE MATERIAL	WIRE TYPE & DIAMETER	PULSE PROCESS SELECTOR 120	60
.5" THICK 5083 H-321 ALUMINUM ALLOY	3/64" DIAMETER 5356 ALUMINUM ALLOY	X	

SHIELD GAS			FLOW RATE
75%HE/25%AR	X		40 CFH

"J" GROOVE

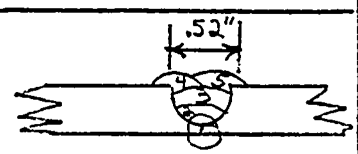
SELECTOR SWITCHES

ARC SUSTAINER HIGH ■

LOW □

POSITION	FLAT - MULTIPLE PASS				
WELDING VOLTAGE	24.5	28	28	25.5	25.5
WELDING CURRENT AMPS	140	150	150	132	132
PEAK CURRENT SETTING	350	400	400	350	350
BACK VOLTAGE SETTING	21	24	24	22	22
WIRE SPEED-IPM	380	420	420	360	360
TRAVEL SPEED-IPM	14.1	11	11	16	16
POTENTIOMETER SETTING WIRE SPEED	2.7	3.1	3.1	2.5	TEN TURN 2.5

AIRCO AHF-NP-AH 35-C2



MACHINE SETTINGS FOR
MILLER PULSTAR 450

BASE MATERIAL	WIRE TYPE & DIAMETER	PULSE PROCESS SELECTOR	
		120	60
.5" THICK 5083 H-321 ALUMINUM ALLOY	3/64" DIAMETER 5356 ALUMINUM ALLOY	X	

SHIELD GAS		FLOW RATE
75%HE/25%AR	X	40 CFH

"J" GROOVE

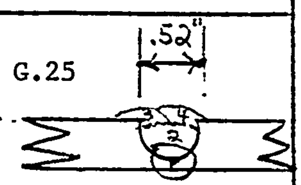
SELECTOR SWITCHES

ARC SUSTAINER HIGH ■

LOW □

POSITION	FLAT - MULTIPLE PASS			
WELDING VOLTAGE	24.5	28.5	25.4	25.2
WELDING CURRENT AMPS	140	150	140	142
PEAK CURRENT SETTING	350	400	350	350
BACK VOLTAGE SETTING	21	24	22	22
WIRE SPEED-IPM	380	450	360	360
TRAVEL SPEED-IPM	14.1	11.5	16	16
POTENTIOMETER SETTING WIRE SPEED	2.7	3.25	2.5	2.5 TEN TURN
BUGO SETTING	E.5	G.5	G.25	G.25

AIRCO AHF-NP-AH 35-C2



MACHINE SETTINGS FOR
MILLER PULSTAR 450
MECHANIZED

BASE MATERIAL	WIRE TYPE & DIAMETER	PULSE PROCESS SELECTOR	
		120	60
.500" THICKNESS 5083 H-321 ALUMINUM ALLOY	3/64" DIAMETER 5356 ALUMINUM ALLOY	X	

SHIELD GAS			FLOW RATE
75%HE/25%AR	X		40 CFH

"J" GROOVE

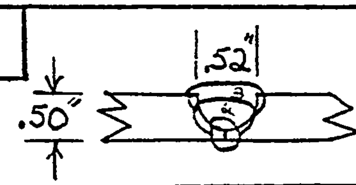
SELECTOR SWITCHES

ARC SUSTAINER HIGH ☒ LOW ☐

POSITION	MECHANIZED FLAT			
WELDING VOLTAGE	25	28	28	
WELDING CURRENT AMPS	150	160	157	
PEAK CURRENT SETTING	350	400	400	
BACK VOLTAGE SETTING	22	25	25	
WIRE SPEED-IPM	375	400	390	
TRAVEL SPEED-IPM	14	11.5	11.5	
POTENTIOMETER SETTING	2.9	3.1	3.0	TEN TURN
AUTO BUG-O	E.5	C.5	C.5	

AHF NP AH 35-C2

I.10



MACHINE SETTINGS FOR
MILLER PULSTAR 450

WELDING PROCEDURE SPECIFICATION
(GUIDE)

This section contains a general welding procedure specification covering out-of-position, one-side, full penetration, manual pulse gas metal arc butt welding of 5000 series aluminum alloy sheet and plate for marine applications. This specification is intended to be used as a guide only.

Also, one page type welding procedure specifications covering each specific test condition and material thickness (.063" - .500") are included.

WELDING PROCEDURE SPECIFICATION
(GUIDE)

ALUMINUM WELDING

OUT-OF-POSITION WELDING OF 5000 SERIES ALUMINUM
ALLOYS USING GMAW POWER SOURCES

1. **SCOPE**

This welding procedure covers the requirements for out-of-position, one-side, full penetration, manual pulse gas metal arc butt welding of the 5000 series aluminum alloys. This procedure is applicable to material thicknesses of .063 inch to .500 inch.

2. TABLE OF CONTENTS

1. Scope
2. Table of Contents
3. References
4. Material Control
    - 4.1 Base Material
    - 4.2 Filler Metals
5. Shielding Gases
6. Electrical Characteristics
7. Position of Welding
8. Facilities Control
9. Procedure Qualification & Welder Performance Qualification
10. Manufacturing Control
    - 10.1 Joint Design and Tolerance
    - 10.2 Material Preparation
    - 10.3 Weld Joint Fit-Up
    - 10.4 Preheat and Interpass Temperatures
    - 10.5 Tack Welding
    - 10.6 Welding Techniques
    - 10.7 Repair Welds
    - 10.8 Post-Weld Heat Treatment
    - 10.9 Peening
11. Quality Assurance

3. REFERENCES

3.1 NAVSHIPS 0900-000-1000 with 0900-000-1001; Fabrication, Welding and Inspection of Ships' Hulls. (June 1969).

3.2 NAVSHIPS 0900-003-8000; Surface Inspection Acceptance Standards (Sept. 1967).

3.3 MIL-STD-0022B (SHIPS); Military Standard Welded Joint Design (May 1969).

3.4 MIL-STD-248C; Welding and Brazing Procedure and Performance Qualification (Oct. 1973).

3.5 MIL-STD-271E; Nondestructive Testing Requirements for Metals.

4. MATERIAL CONTROL

4.1 Base Material

The base material shall comply with one of the following specifications:

MATERIAL SPECIFICATION	ALUMINUM ALLOY COMPOSITION	TYPE OF MATERIAL
QQ-A-250/6	5083	Plate & Sheet
QQ-A-250/19	5086	Plate & Sheet
QQ-A-250/8	5052	Plate & Sheet
QQ-A-250/20	5456	Plate & Sheet
QQ-A-250/10	5454	Plate & Sheet
QQ-A-225/7	5052	Bar, Rod & Wire
QQ-A-200/7	5456	Bar, Rod, Shapes, Tube, Wire
QQ-A-200/6	5454	Bar, Rod, Shapes, Tube, Wire
QQ-A-200/5	5086	Bar, Rod, Shapes, Tube, Wire
QQ-A-200/4	5083	Bar, Rod, Shapes, Tube, Wire

4.2 Filler Metals

Filler wire alloys for welding aluminum shall be in accordance with the following chart:

Base Alloy	5052	5083	5086	5454	5456
5052	5356				
5083	5356	5356			
5086	5356	5356	5356		
5454	5356	5356	5356	5556	
5456	5356	5356	5356	5556	5556

Filler metals shall conform to AWS A5.10-80, Aluminum and Aluminum Alloy Bare Welding Rods & Electrodes.

Filler metals shall be protected from contamination at all times and shall be stored in a warm dry area.

5. SHIELDING GASES

GASES	SPECIFICATION OR SOURCE
ARGON	MIL-A-18455
HELIUM	FEDERAL SPECIFICATION BB-H-1168, GRADE A
75% HELIUM/25% ARGON	LINDE DIVISION UNION CARBIDE AIR REDUCTION OR EQUIVALENT

6. **ELECTRICAL CHARACTERISTICS**

The current used for the GMAW process shall be direct current, reverse polarity.

7. **POSITION OF WELDING**

The base material may be welded in all position (flat, vertical-up, horizontal and overhead) using appropriate diameter filler wire and current settings. Where practicable, the weldments shall be positioned for flat (downhand) welding.

8. **FACILITIES CONTROL**

The welding equipment shall be such that the weld quality requirements of this specification can be met with reliability and consistency.

9. **PROCEDURE QUALIFICATION & WELDER PERFORMANCE QUALIFICATION**

Procedure qualification and welder performance qualification shall be per the requirements of MIL-STD-248c.

10. **MANUFACTURING CONTROL**

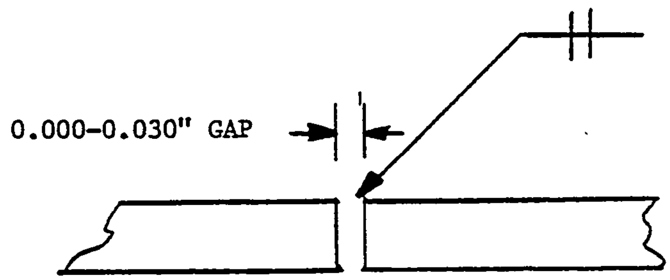
10.1 **Joint Design and Tolerance**

Unless otherwise stated on the plan, weld joint designs and tolerances shall be in accordance with this specification. See Sketch.

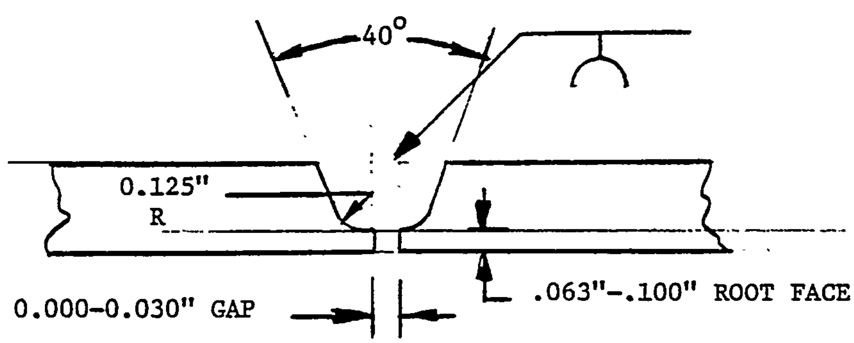
10.2 **Material Preparation**

Weld joint edges may be prepared by mechanical processes such as machining, filing, routing, grinding, chipping. Prior to welding, surface oxide films on the areas to be welded shall be removed by using a clean stainless steel wire brush. Brushes may be either manual or power driven. Bristle diameters of the stainless steel wire brushes shall be .010 to .015 inch in diameter. Welding on the cleaned weld joint surfaces shall he done within 8 hours if feasible.

SQUARE BUTT JOINT
PLATES FORMING BUTTS WITH NO BACKING MEMBER SHALL BE FITTED METAL-TO-METAL. PLATES .125″ AND THINNER SHALL BE CUT SQUARE. MAXIMUM ALLOWABLE GAP SHALL BE 0.030 INCH.



"J" GROOVE JOINTS
PLATES FORMING BUTTS WITH NO BACKING MEMBER SHALL BE FITTED METAL-TO-METAL. PLATES OVER .125″ THICK SHALL BE MACHINED WITH A "J" GROOVE WITH AN ANGLE OF 20° AND 0.100 INCH MAXIMUM ROOT FACE (LAND).



NOTE: SEE SECTION 10.1

WELD JOINT DESIGNS FOR
ONE-SIDE, OUT-OF-POSITION, FULL PENETRATION
MANUAL PULSE GAS METAL ARC BUTT WELDING
OF
5000 SERIES ALUMINUM ALLOY SHEETS AND PLATE

10. MANUFACTURING CONTROL (continued)

10.2 Material Preparation (continued)

The weld joint areas and surfaces on which welds are to be deposited shall be free of grease, oil, rust, slag, water, paint or any other harmful matter.

Build up by welding on the weld joint surfaces to correct oversize root openings or errors in joint preparation shall not exceed 3/8 inch on each joint member. The areas built up by welding shall be ground smooth and faired smoothly into the adjacent material thickness.

Weld joint edges shall be free of laminations and sharp notches which will interfere with welding.

10.3 Weld Joint Fit-Up

Unless otherwise stated on the plans, the weld joint fit-up shall meet the requirements of this specification.
Fit-up shall be metal-to-metal or range from .000 to .030 inch.

10.4 Preheat and Interpass Temperatures

In fabricating heavy weldments, a temperature of at least 60°F in the weldment shall be obtained and maintained until all welding has been completed. Sufficient preheat shall be used *to remove* moisture. Preheat temperature shall not exceed 300°F, as indicated by approved temperature indicating devices.

10.5 Tack Welding

All tack welding shall be done by personnel qualified per MIL-STD-248C.

Tack welds shall be made with the same type of electrode to be used in the final weld.

Tack welds shall be kept as small as practicable or the excess weld reinforcement shall be chiseled to a size small enough so that they can be absorbed into the final weld. Cracked tack welds and those which are unsuitable to incorporate into the final weld shall be removed.

10.6 Welding Techniques

Stringer weld bead passes shall be utilized for all root weld bead deposits so that one-side, full penetration welds may be attained.

Weld machine settings shall be approximately as shown in the chart below:

PROCESS	WIRE DIAMETER	OPERATING CURRENT RANGE (AMPs)	OPERATING VOLTAGE RANGE	SHIELDING GAS
Manual	.030	25-90	15-20	Argon or
Pulse	.035	30-100	16-20	75%He/25%Ar
G M 4 A W	3/64	40-150	17-23	
	1/16	45-300	17-28	

In multiple pass welds, each pass shall be wire brushed before depositing subsequent passes. Weld penetration in square groove and “J” joints welded from one-side shall be complete as evidenced by a weld bead and the absence of a joint line on the side opposite that from which the weld was completed. The roots of weld joints must have complete penetration. The weld root area shall be visually examined for defects and weld deposit penetration depth/width consistency.

10.7 Repair Welds

Repair welding shall be limited to those locations which cannot be corrected by grinding. Repair welds shall be made to the same standards as the original work.

Grinding of any defects shall produce a smooth blending of the weld into the surrounding surface of the base material.

Undercut in excess of 10% of the thinner member, whichever is less shall be repaired. Excessive undercut may be repaired by welding or grinding. The repair of undercut by welding shall be accomplished by depositing a weld bead in the undercut area which will fair into the existing weld.

10. <u>MANUFACTURING CONTROLS</u> (continued)

10.7 <u>Repair Welds</u> (continued)

Unless otherwise stated on the plans (drawing), weld reinforcement shall be a minimum weld penetration of 100% and without evidence of a joint line.

Maximum weld reinforcement shall be 3/32 inch.

Excessively convex weld bead configurations are to be ground and faired smoothly into adjacent metal plates/sheets.

Repair welds shall not be flushed except in areas where appearance requires removal, such as the outside of the shell plating and exposed structure in quarters.

10.8 <u>Post-Weld Heat Treatment (Stress Relief)</u>

Unless otherwise stated on the plans or applicable specifications, no post-weld heat treatment is required.

10.9 <u>Peening</u>

Peening of aluminum welds shall not be done on the first and *last* weld passes.

11. <u>QUALITY ASSURANCE</u>

Quality Assurance shall ensure that all the requirements of this specification are met.

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TODD PACIFIC SHIPYARDS CORPORATION

SEATTLE DIVISION

WELDING PROCEDURE SPECIFICATION

DESCRIPTION
ALUMINUM WELDING; OUT-OF-POSITION FULL PENETRATION MANUAL GAS METAL ARC BUTT WELDING OF 5000 SERIES ALUMINUM ALLOY SHEET & PLATE

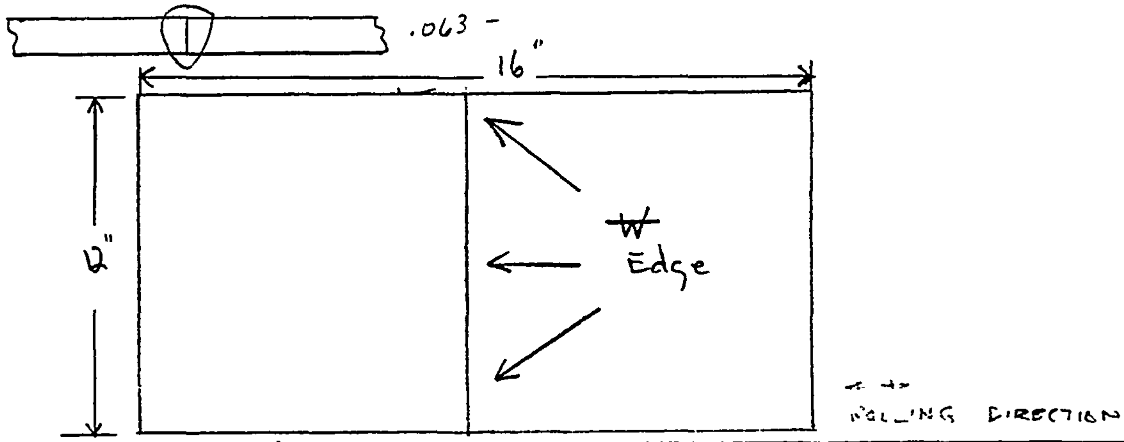
WELDER QUALIF.	MIL-STD-248C	PROCEDURE QUALIF.STD.	MIL-STD-248C;MIL-STD-278D NAVSHIPS 0900-000-1000/1
BASE METALS	0.063" 5086 H32 QQ-A-150/7	PROCESS:	GAS METAL ARC WELDING (GMAW) SHORT ARC
SPEC. TYPE FILLER METAL	AWS A5.10-80 ER5556	POWER SOURCE;MODEL/TYPE	AIRCO PULSE ARC 350
		POLARITY	DC RP
POSITION OF WELD	VERTICAL-UP	FLUX;SPEC/SIZE/TYPE:	NA
		GAS: FLOW RATE/TYPE	75%HE/25%AR 40 CFH
JOINT PREPARATION & SIDE NUMBER	REMOVE SHEAR OR SAW MARKS FROM FAYING SURFACE BY SCRAPING, FILING OR ROUTING BOTH SIDES	TORCH TYPE / CUP SIZE	BINZEL / 3/4 INCH ORIFICE
INTERPASS CLEANING	STAINLESS STEEL WIRE BRUSHING		
REPAIRS	REPAIR WELDS SHALL BE MADE TO THE SAME STANDARDS AS THE ORIGINAL WORK.		
PREHEAT	AMBIENT	INTERPASS TEMPERATURE	NA
POSTHEAT TEMPERATURE	NA	ELECTRODE CONTROL	TWPS 4003
HEAT TREATMENT	NA		
WELD TECHNIQUE	GMAW STRINGER BEAD		

TRAVEL SPEED (I.P.M.)	FILLER METAL SIZE	AMPERAGE RANGE	ARC VOLTAGE RANGE	POSITION
18	3/64"	50	15	VERTICAL

NOTES:

JOINT DESIGN: BIS.1/MIL. STD. 22 THICK RANGE QUAL.

SKETCH OF WELD LOCATION & TYPICAL PASS SEQUENCE



APPROVALS: [signature] [signature: James C. Johnston]

TODD PACIFIC SHIPYARDS CORPORATION

SEATTLE DIVISION

WELDING PROCEDURE SPECIFICATION

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DESCRIPTION

ALUMINUM WELDING; OUT-OF-POSITION FULL PENETRATION MANUAL GAS METAL ARC BUTT WELDING OF 5000 SERIES ALUMINUM ALLOY SHEET & PLATE

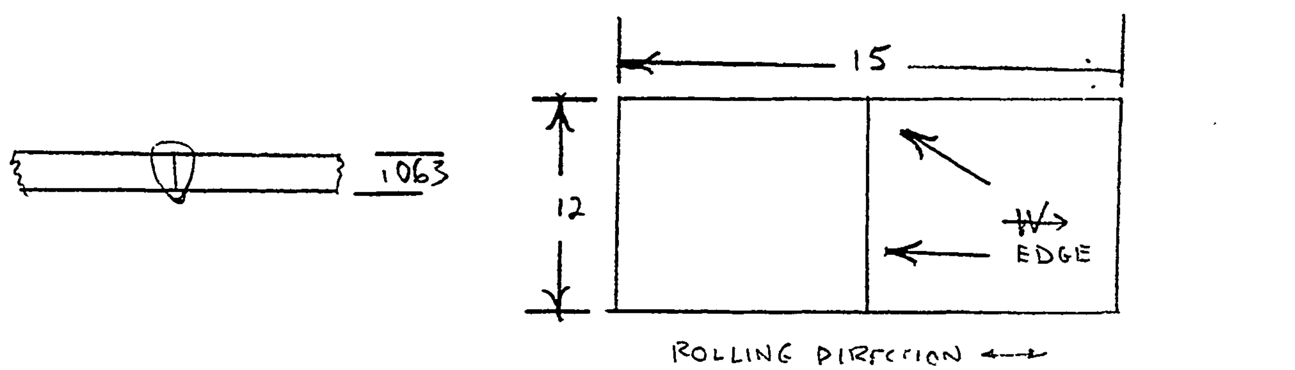
WELDER QUALIF.	MIL-STD-248C	PROCEDURE QUALIF.STD.	MIL-STD-248C;MIL-STD-278D NAVSHIPS 0900-000-1000/1
BASE METALS	.063" 5086 H-32 QQA150/7	PROCESS:	GAS METAL ARC WELDING SHORT ARC
SPEC. TYPE FILLER METAL	AWS A5.10-80 ER5356	POWER SOURCE;MODEL/TYPE	AIRCO PULSE ARC 350
		POLARITY	DCRP
POSITION OF WELD	VERTICAL-UP	FLUX;SPEC/SIZE/TYPE:	NA
		GAS: FLOW RATE/TYPE	75%HE/25%AR 40 CFH
JOINT PREPARATION & SIDE NUMBER	REMOVE SHEAR OR SAW MARKS FROM FAYING SURFACE BY SCRAPING FILING OR ROUTING BOTH SIDES	TORCH TYPE	BINZEL
		CUP SIZE	3/4 INCH ORIFICE
INTERPASS CLEANING	STAINLESS STEEL WIRE BRUSHING		
REPAIRS	REPAIR WELDS SHALL BE MADE TO THE SAME STANDARDS AS ORIGINAL WORK.		
PREHEAT	AMBIENT	INTERPASS TEMPERATURE	NA
POSTHEAT TEMPERATURE	NA	ELECTRODE CONTROL	TWPS 4003
HEAT TREATMENT	NA		
WELD TECHNIQUE	GMAW STRINGER BEAD		

TRAVEL SPEED (I.P.M.)	FILLER METAL SIZE	AMPERAGE RANGE	ARC VOLTAGE RANGE	POSITION
18.5	3/64	40	15.5	VERTICAL

NOTES:

JOINT DESIGN: B1S.1/MIL.STD 22 THICK RANGE QUAL.

SKETCH OF WELD LOCATION & TYPICAL PASS SEQUENCE



APPROVALS: J N Hitch James C Ja...

PACIFIC SHIPYARDS CORPORATION

SEATTLE DIVISION

WELDING PROCEDURE SPECIFICATION

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DESCRIPTION
ALUMINUM WELDING; OUT-OF-POSITION FULL PENETRATION MANUAL GAS METAL ARC BUTT WELDING OF 5000 SERIES ALUMINUM ALLOY SHEET & PLATE

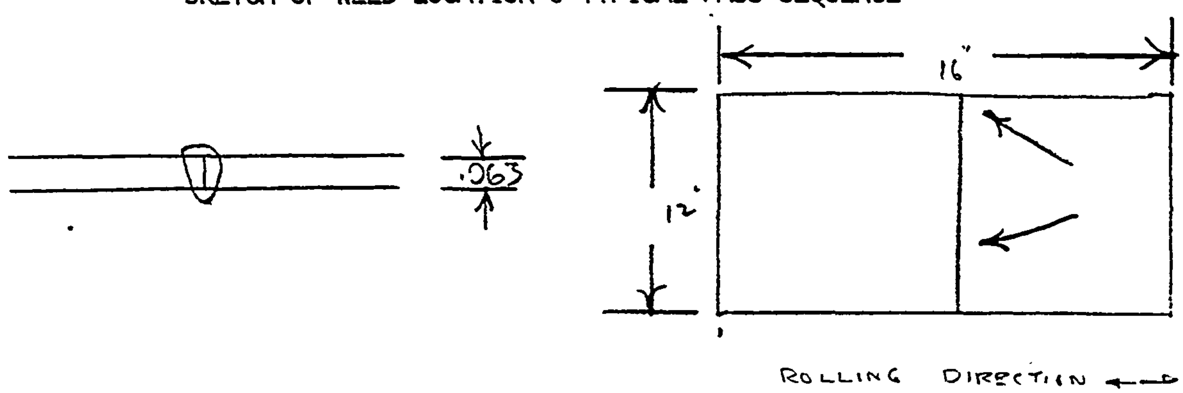
WELDER QUALIF.	MIL-STD-248C	PROCEDURE QUALIF.STD.	MIL-STD-248C;MIL-STD-278D NAVSHIPS 0900-000-1000/1
BASE METALS	.063" 5086 H-32 QQ-A-150/7	PROCESS:	GAS METAL ARC WELDING (GMAW) SHORT ARC
SPEC. TYPE FILLER METAL	AWS A5.10-80 ER5556	POWER SOURCE;MODEL/TYPE	AIRCO PULSE ARC 350 POLARITY DC RP
POSITION OF WELD	HORIZONTAL	FLUX;SPEC/SIZE/TYPE:	NA
		GAS: FLOW RATE/TYPE	40 CFH 75%HE/25%AR
JOINT PREPARATION & SIDE NUMBER	REMOVE SHEAR OR SAW MARKS FROM FAYING SURFACE BY SCRAPING FILING OR ROUTING BOTH SIDES	TORCH TYPE	BINZEL CUP SIZE 3/4 INCH ORIFICE
INTERPASS CLEANING	STAINLESS STEEL WIRE BRUSHING		
REPAIRS	REPAIR WELDS SHALL BE MADE TO THE SAME STANDARDS AS THE ORIGINAL WORK		
PREHEAT	AMBIENT	INTERPASS TEMPERATURE	NA
POSTHEAT TEMPERATURE	NA	ELECTRODE CONTROL	TWPS 4003
HEAT TREATMENT	NA		
WELD TECHNIQUE	GMAW STRINGER BEAD		

TRAVEL SPEED (I.P.M.)	FILLER METAL SIZE	AMPERAGE RANGE	ARC VOLTAGE RANGE	POSITION
18	3/64"	50	15	HORIZONTAL

NOTES:

JOINT DESIGN: B1S.1/MIL.STD. 22 THICK RANGE QUAL.

SKETCH OF WELD LOCATION & TYPICAL PASS SEQUENCE



APPROVALS: J H Nitch J. C. Johnston

PACIFIC SHIPYARDS CORPORATION
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WELDING PROCEDURE SPECIFICATION

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DESCRIPTION
ALUMINUM WELDING; OUT-OF-POSITION FULL PENETRATION MANUAL GAS METAL ARC BUTT WELDING OF 5000 SERIES ALUMINUM ALLOY SHEET & PLATE

WELDER QUALIF.: MIL-STD-248C
PROCEDURE QUALIF.STD.: MIL-STD-248C;MIL-STD-278D NAVSHIPS 0900-000-1000/1

BASE METALS: 0.063" 5086 H-32 QQ-A-150/7
PROCESS: GAS METAL ARC WELDING (GMAW) SHORT ARC

SPEC. TYPE FILLER METAL: AWS A5.10-80 ER5556
POWER SOURCE;MODEL/TYPE: AIRCO PA350
POLARITY: DC RP

POSITION OF WELD: OVERHEAD
FLUX;SPEC/SIZE/TYPE: NA
GAS: FLOW RATE/TYPE: 40 CFH 75%HE/25%AR

JOINT PREPARATION & SIDE NUMBER: REMOVE SHEAR OR SAW MARKS FROM FAYING SURFACE BY SCRAPING, FILING, OR ROUTING BOTH SIDES
TORCH TYPE: BINZEL
CUP SIZE: 3/4 INCH ORIFICE

INTERPASS CLEANING: STAINLESS STEEL WIRE BRUSHING

REPAIRS: REPAIR WELDS SHALL BE MADE TO THE SAME STANDARDS AS THE ORIGINAL WORK

PREHEAT: AMBIENT
INTERPASS TEMPERATURE: NA

POSTHEAT TEMPERATURE: NA
ELECTRODE CONTROL: TWPS 4003

HEAT TREATMENT: NA

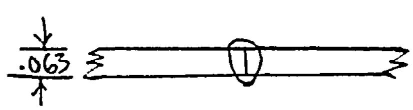
WELD TECHNIQUE: GMAW STRINGER BEAD

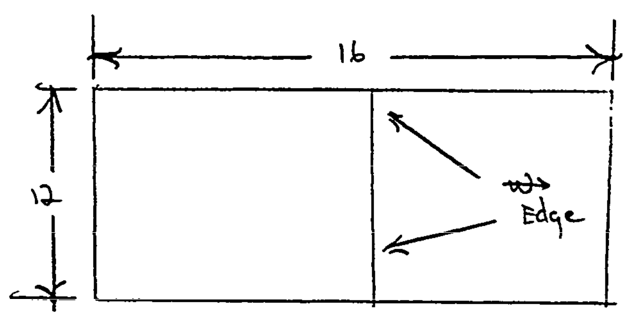
TRAVEL SPEED (I.P.M.)	FILLER METAL SIZE	AMPERAGE RANGE	ARC VOLTAGE RANGE	POSITION
20	3/64"	50	15.5	OVERHEAD

NOTES:

JOINT DESIGN: BIS.1/MIL. STD. 22
THICK RANGE QUAL.

SKETCH OF WELD LOCATION & TYPICAL PASS SEQUENCE





APPROVALS: J H Hitch James C Johnston

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WELDING PROCEDURE SPECIFICATION

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DESCRIPTION
ALUMINUM WELDING; OUT-OF-POSITION PENETRATION MANUAL GAS METAL ARC BUTT WELDING OF 5000 SERIES ALUMINUM ALLOY SHEET & PLATE

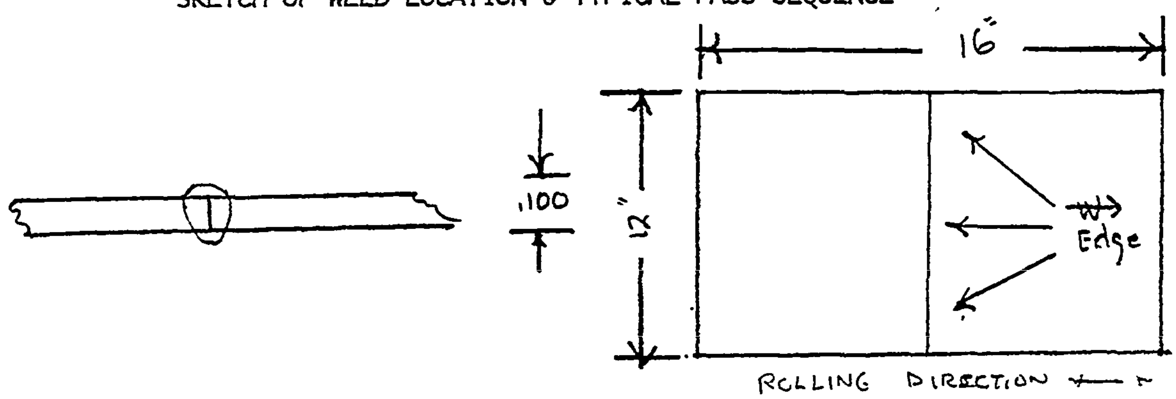
WELDER QUALIF.	MIL-STD-248C	PROCEDURE QUALIF.STD.	MIL-STD-248C;MIL-STD-278D NAVSHIPS 0900-000-1000/1
BASE METALS	0.100" 5086 H-32 QQ-A-150/7	PROCESS:	GAS METAL ARC WELDING (GMAW) PULSED ARC
SPEC. TYPE FILLER METAL	AWS A5.10-80 ER5356	POWER SOURCE;MODEL/TYPE	AIRCO PA3A
		POLARITY	DC RP
POSITION OF WELD	VERTICAL-UP	FLUX;SPEC/SIZE/TYPE:	NA
		GAS: FLOW RATE/TYPE	40 CFH 75%HE/25%AR
JOINT PREPARATION & SIDE NUMBER	REMOVE SHEAR OR SAW MARKS FROM FAYING SURFACE BY SCRAPING, FILING OR ROUTING BOTH SIDES	TORCH TYPE	BINZEL
		CUP SIZE	3/4 INCH ORIFICE
INTERPASS CLEANING	STAINLESS STEEL		
REPAIRS	REPAIR WELDS SHALL BE MADE TO THE SAME STANDARDS AS ORIGINAL WORK		
PREHEAT	AMBIENT	INTERPASS TEMPERATURE	NA
POSTHEAT TEMPERATURE	NA	ELECTRODE CONTROL	TWPS 4003
HEAT TREATMENT	NA		
WELD TECHNIQUE	GMAW STRINGER BEAD		

TRAVEL SPEED (I.P.M.)	FILLER METAL SIZE	AMPERAGE RANGE	ARC VOLTAGE RANGE	POSITION
15.6	.030"	45	19	VERTICAL

NOTES:

JOINT DESIGN: BTS.1/MIL. STD. 22 THICK RANGE QUAL.

SKETCH OF WELD LOCATION & TYPICAL PASS SEQUENCE



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WELDING PROCEDURE SPECIFICATION

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DESCRIPTION

OUT-OF-POSOTION, ONE SIDE, FULL PENETRATION MANUAL GAS METAL ARC BUTT WELDING OF ALUMINUM ALLOY SHEETS AND PLATES FOR MARINE APPLICATION

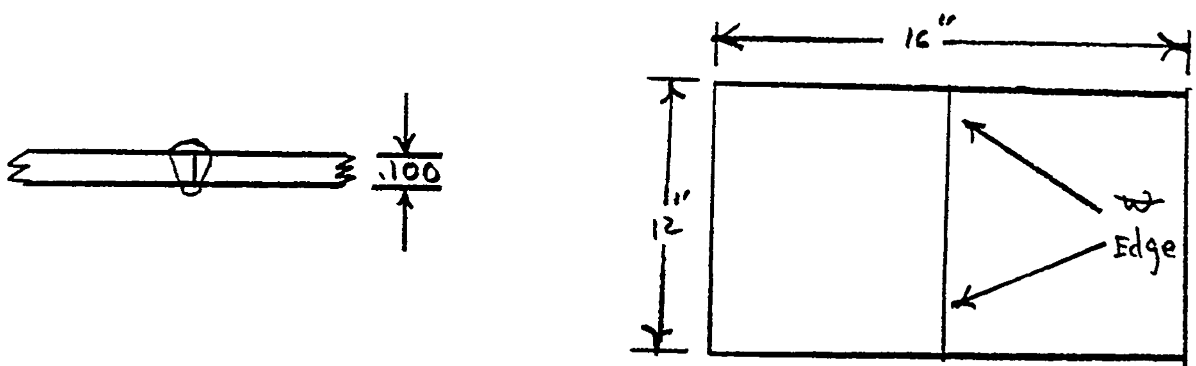
WELDER QUALIF.	MIL-STD-248C	PROCEDURE QUALIF.STD.	MIL-STD-248C;MIL-STD-278D NAVSHIPS 0900-000-1000/1
BASE METALS	0.100" 5086 H32 QQ-A-150/7	PROCESS:	GAS METAL ARC WELDING (GMAW) PULSE ARC
SPEC. TYPE FILLER METAL	AWS A5.10-80 ER 5356	POWER SOURCE;MODEL/TYPE	PA 3A AIRCO
		POLARITY	DC RP
POSITION OF WELD	HORIZONTAL	FLUX;SPEC/SIZE/TYPE:	NA
		GAS: FLOW RATE/TYPE	40 CFH 75%HE/25%AR
JOINT PREPARATION & SIDE NUMBER	REMOVE SHEAR OR SAW MARKS FROM FAYING SURFACE BY SCRAPING, FILING OR ROUTING BOTH SIDES	TORCH TYPE	NP C2
		CUP SIZE	3/4 INCH ORIFICE
INTERPASS CLEANING	STAINLESS STEEL WIRE BRUSHING		
REPAIRS	REPAIR WELDS SHALL BE MADE TO THE SAME STANDARDS AS ORIGINAL WORK		
PREHEAT	AMBIENT	INTERPASS TEMPERATURE	NA
POSTHEAT TEMPERATURE	NA	ELECTRODE CONTROL	TWPS 4003
HEAT TREATMENT	NA		
WELD TECHNIQUE	GMAW STRINGER BEAD		

TRAVEL SPEED (I.P.M.)	FILLER METAL SIZE	AMPERAGE RANGE	ARC VOLTAGE RANGE	POSITION
18	.035"	55	19	HORIZONTAL

NOTES:

JOINT DESIGN: B1S.1/MIL.STD. 22 THICK RANGE QUAL.

SKETCH OF WELD LOCATION & TYPICAL PASS SEQUENCE



APPROVALS: J H Nitel James C Johnston

TODD PACIFIC SHIPYARDS CORPORATION

SEATTLE DIVISION

WELDING PROCEDURE SPECIFICATION

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DESCRIPTION
ALUMINUM WELDING; OUT-OF-POSITION FULL PENETRATION MANUAL GAS METAL ARC BUTT WELDING OF 5000 SERIES ALUMINUM ALLOY SHEET & PLATE

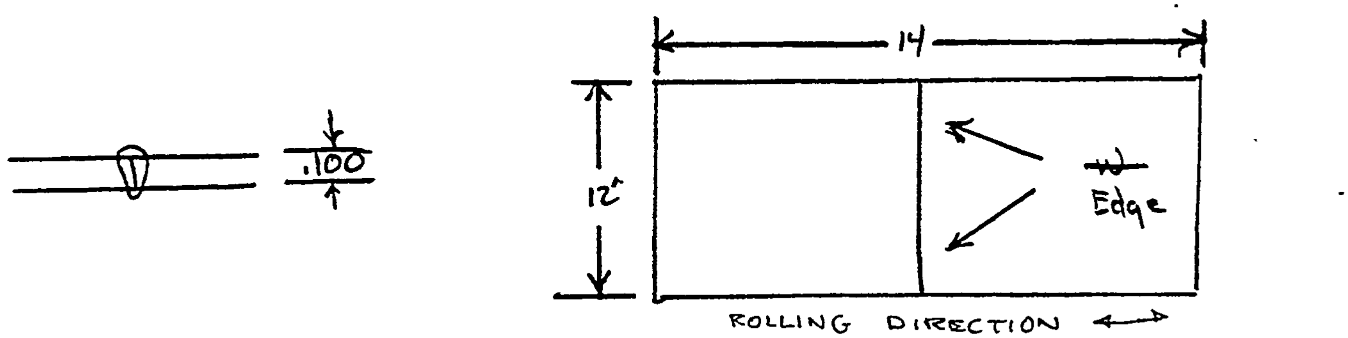
WELDER QUALIF.	MIL-STD-248C	PROCEDURE QUALIF.STD.	MIL-STD-248C;MIL-STD-278D NAVSHIPS 0900-000-1000/1
BASE METALS	0.100" 5086 H-32 QQ-A-150/7	PROCESS:	GAS METAL ARC WELDING (GMAW) SHORT ARC
SPEC. TYPE FILLER METAL	AWS A5.10-80 ER 5356	POWER SOURCE;MODEL/TYPE	AIRCO PA 350
		POLARITY	DC RP
POSITION OF WELD	OVERHEAD	FLUX;SPEC/SIZE/TYPE:	NA
		GAS: FLOW RATE/TYPE	40 CFH 75%HE/25%AR
JOINT PREPARATION & SIDE NUMBER	REMOVE SHEAR OR SAW MARKS FROM FAYING SURFACE BY SCRAPING, FILING OR ROUTING BOTH SIDES	TORCH TYPE	BINZEL
		CUP SIZE	3/4 INCH ORIFICE
INTERPASS CLEANING	STAINLESS STEEL WIRE BRUSHING		
REPAIRS	REPAIR WELDS SHALL BE MADE TO THE SAME STANDARDS AS ORIGINAL WORK		
PREHEAT	AMBIENT	INTERPASS TEMPERATURE	NA
POSTHEAT TEMPERATURE	NA	ELECTRODE CONTROL	TWPS 4003
HEAT TREATMENT	NA		
WELD TECHNIQUE	GMAW STRINGER BEAD		

TRAVEL SPEED (I.P.M.)	FILLER METAL SIZE	AMPERAGE RANGE	ARC VOLTAGE RANGE	POSITION
17	3/64"	70	16	OVERHEAD

NOTES:

JOINT DESIGN: B1S.1/MIL. STD. 22 THICK RANGE QUAL.

SKETCH OF WELD LOCATION & TYPICAL PASS SEQUENCE



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TODD PACIFIC SHIPYARDS CORPORATION

SEATTLE DIVISION

WELDING PROCEDURE SPECIFICATION

DESCRIPTION
ALUMINUM WELDING; OUT-OF-POSITION FULL PENETRATION MANUAL GAS METAL ARC BUTT WELDING OF 5000 SERIES ALUMINUM ALLOY SHEET & PLATE

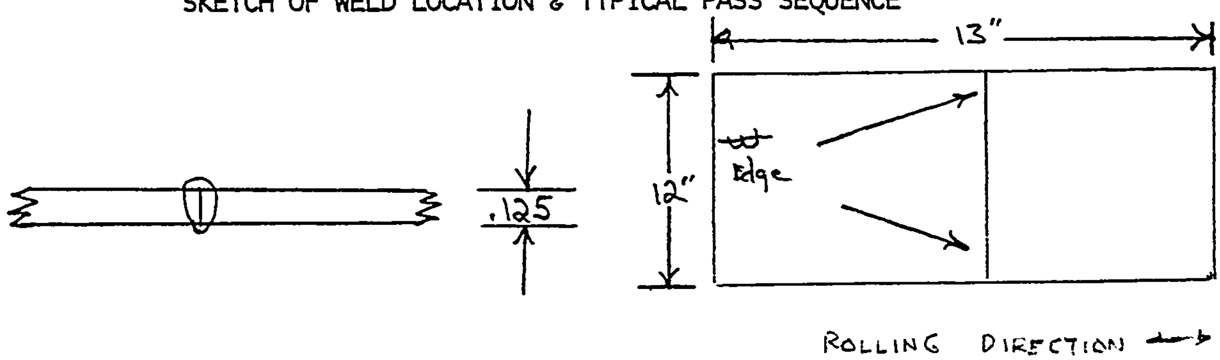
WELDER QUALIF.	MIL-STD-248C	PROCEDURE QUALIF.STD.	MIL-STD-248C;MIL-STD-278D NAVSHIPS 0900-000-1000/1
BASE METALS	0.125"5083 H-323 QQ-A-250/6	PROCESS:	GAS METAL ARC WELDING (GMAW) SHORT ARC
SPEC. TYPE FILLER METAL	AWS A5.10-80 ER 5556	POWER SOURCE;MODEL/TYPE	AIRCO PULSE ARC 350
		POLARITY	DC RP
POSITION OF WELD	VERTICAL-UP	FLUX;SPEC/SIZE/TYPE:	NA
		GAS: FLOW RATE/TYPE	40 CFH 75%HE/25%AR
JOINT PREPARATION & SIDE NUMBER	REMOVE SHEAR OR SAW MARKS FROM FAYING SURFACE BY SCRAPING, FILING OR ROUTING BOTH SIDES	TORCH TYPE	BINZEL
		CUP SIZE	3/4 INCH ORIFICE
INTERPASS CLEANING	STAINLESS STEEL WIRE BRUSHING		
REPAIRS	REPAIR WELDS SHALL BE MADE TO THE SAME STANDARDS AS ORIGINAL WORK		
PREHEAT	AMBIENT	INTERPASS TEMPERATURE	NA
POSTHEAT TEMPERATURE	NA	ELECTRODE CONTROL	TWPS 4003
HEAT TREATMENT	NA		
WELD TECHNIQUE	GMAW STRINGER BEADS		

TRAVEL SPEED (I.P.M.)	FILLER METAL SIZE	AMPERAGE RANGE	ARC VOLTAGE RANGE	POSITION
12.8	3/64"	70	17	VERTICAL

NOTES:

JOINT DESIGN: B1S.1/MIL. STD. 22 THICK RANGE QUAL.

SKETCH OF WELD LOCATION & TYPICAL PASS SEQUENCE



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TODD PACIFIC SHIPYARDS CORPORATION

SEATTLE DIVISION

WELDING PROCEDURE SPECIFICATION

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DESCRIPTION
ALUMINUM WELDING; OUT-OF-POSITION FULL PENETRATION MANUAL GAS METAL ARC BUTT WELDING OF 5000 SERIES ALUMINUM ALLOY SHEET & PLATE

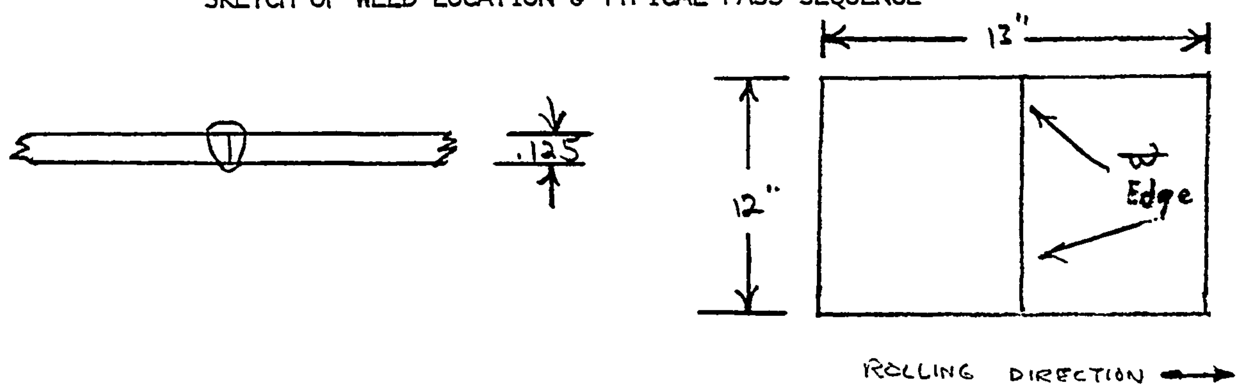
WELDER QUALIF.	MIL-STD-248C	PROCEDURE QUALIF.STD.	MIL-STD-248C;MIL-STD-278D NAVSHIPS 0900-000-1000/1
BASE METALS	0.125"5083 H-323 QQ-A-250/6	PROCESS:	GAS METAL ARC WELDING (GMAW) SHORT ARC
SPEC. TYPE FILLER METAL	AWS A5.10-80 ER5356	POWER SOURCE;MODEL/TYPE	AIRCO PULSE ARC 350
		POLARITY	DC RP
POSITION OF WELD	VERTICAL-UP	FLUX;SPEC/SIZE/TYPE:	NA
		GAS: FLOW RATE/TYPE	40 CFH 75%HE/25%AR
JOINT PREPARATION & SIDE NUMBER	REMOVE SHEAR OR SAW MARKS FROM FAYING SURFACE BY SCRAPING, FILING OR ROUTING BOTH SIDES	TORCH TYPE	BINZEL
		CUP SIZE	3/4 INCH ORIFICE
INTERPASS CLEANING	STAINLESS STEEL WIRE BRUSHING		
REPAIRS	REPAIR WELDS SHALL BE MADE TO THE SAME STANDARDS AS ORIGINAL WORK		
PREHEAT	AMBIENT	INTERPASS TEMPERATURE	NA
POSTHEAT TEMPERATURE	NA	ELECTRODE CONTROL	TWPS 4003
HEAT TREATMENT	NA		
WELD TECHNIQUE	GMAW STRINGER BEAD		

TRAVEL SPEED (I.P.M.)	FILLER METAL SIZE	AMPERAGE RANGE	ARC VOLTAGE RANGE	POSITION
14.1	3/64"	70	17	VERTICAL

NOTES:

JOINT DESIGN: B1S.1/MIL. STD. 22 THICK RANGE QUAL.

SKETCH OF WELD LOCATION & TYPICAL PASS SEQUENCE



APPROVALS: J H Hitil James C Johnston

TODD PACIFIC SHIPYARDS CORPORATION

SEATTLE DIVISION

WELDING PROCEDURE SPECIFICATION

TWPS NO.:	C.30
REV:	
ISSUED:	
PAGE:	

DESCRIPTION
ALUMINUM WELDING; OUT-OF-POSITION FULL PENETRATION MANUAL GAS METAL ARC BUTT WELDING OF 5000 SERIES ALUMINUM ALLOY SHEET & PLATE

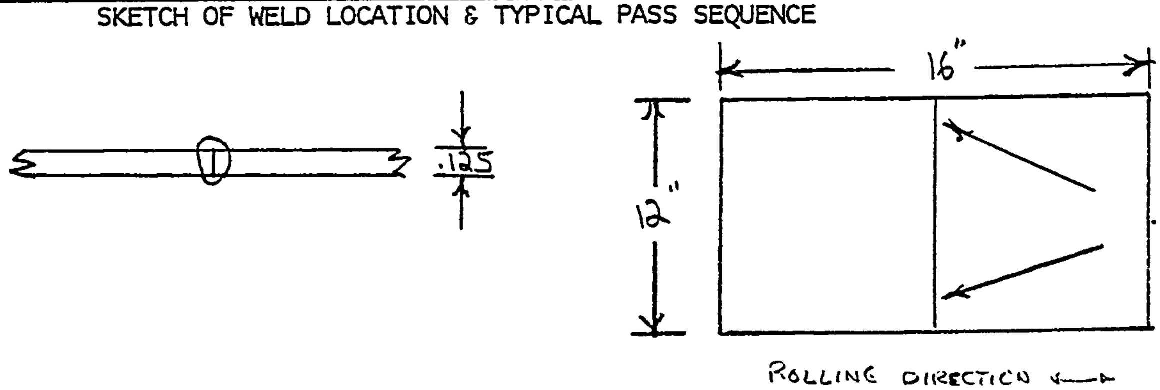
WELDER QUALIF.	MIL-STD-248C	PROCEDURE QUALIF.STD.	MIL-STD-248C;MIL-STD-278D NAVSHIPS 0900-000-1000/1
BASE METALS	0.125" 5083 H-323 QQ-A-250/6	PROCESS:	GAS METAL ARC WELDING (GMAW) SHORT ARC
SPEC. TYPE FILLER METAL	AWS A5.10-80 ER 5556	POWER SOURCE;MODEL/TYPE	AIRCO PULSE ARC 350
		POLARITY	DC RP
POSITION OF WELD	HORIZONTAL	FLUX;SPEC/SIZE/TYPE:	NA
		GAS: FLOW RATE/TYPE	40 CFH 75%HE/25%AR
JOINT PREPARATION & SIDE NUMBER	REMOVE SHEAR OR SAW MARKS FROM FAYING SURFACE BY SCRAPING, FILING OR ROUTING BOTH SIDES	TORCH TYPE BINZEL	CUP SIZE 3/4 INCH ORIFICE
INTERPASS CLEANING	STAINLESS STEEL WIRE BRUSHING		
REPAIRS	REPAIR WELDS SHALL BE MADE TO THE SAME STANDARDS AS ORIGINAL WORK		
PREHEAT	AMBIENT	INTERPASS TEMPERATURE	NA
POSTHEAT TEMPERATURE	NA	ELECTRODE CONTROL	TWPS 4003
HEAT TREATMENT	NA		
WELD TECHNIQUE	GMAW STRINGER BEAD		

TRAVEL SPEED (I.P.M.)	FILLER METAL SIZE	AMPERAGE RANGE	ARC VOLTAGE RANGE	POSITION
15	3/64"	85	19.5	HORIZONTAL

NOTES:

JOINT DESIGN: B1S.1/MIL. STD.22 THICK RANGE QUAL.

SKETCH OF WELD LOCATION & TYPICAL PASS SEQUENCE



APPROVALS: [signature] [signature]

PACIFIC SHIPYARDS CORPORATION

SEATTLE DIVISION

WELDING PROCEDURE SPECIFICATION

TWPS NO.: C.46

REV:

ISSUED:

PAGE:

DESCRIPTION
ALUMINUM WELDING; OUT-OF-POSITION FULL PENETRATION MANUAL GAS METAL ARC BUTT WELDING OF 5000 SERIES ALUMINUM ALLOY SHEET & PLATE

WELDER QUALIF.	MIL-STD-248C	PROCEDURE QUALIF. STD.	MIL-STD-248C; MIL-STD-278D NAVSHIPS 0900-000-1000/1
BASE METALS	0.125" 5083 H-323 QQ-A-250/6	PROCESS:	GAS METAL ARC WELDING (GMAW) SHORT ARC
SPEC. TYPE FILLER METAL	AWS A5.10-80 ER 5356	POWER SOURCE; MODEL/TYPE	AIRCO PULSE ARC 350
		POLARITY	DC RP
POSITION OF WELD	OVERHEAD	FLUX; SPEC/SIZE/TYPE:	NA
		GAS: FLOW RATE/TYPE	40 CFH 75%HE/25%AR
JOINT PREPARATION & SIDE NUMBER	REMOVE SHEAR OR SAW MARKS FROM FAYING SURFACE BY SCRAPING, FILING OR ROUTING BOTH SIDES	TORCH TYPE	BINZEL
		CUP SIZE	3/4 INCH ORIFICE
INTERPASS CLEANING	STAINLESS STEEL WIRE BRUSHING		
REPAIRS	REPAIR WELDS SHALL BE MADE TO THE SAME STANDARDS AS ORIGINAL WORK		
PREHEAT	AMBIENT	INTERPASS TEMPERATURE	NA
POSTHEAT TEMPERATURE	NA	ELECTRODE CONTROL	TWPS 4003
HEAT TREATMENT	NA		
WELD TECHNIQUE	GMAW STRINGER BEAD		

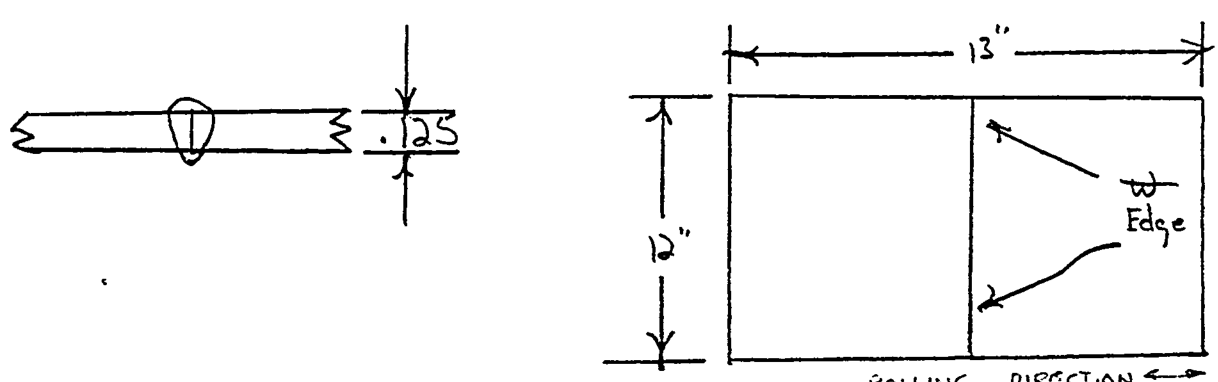
TRAVEL SPEED (I.P.M.)	FILLER METAL SIZE	AMPERAGE RANGE	ARC VOLTAGE RANGE	POSITION
20	3/64"	105	15	OVERHEAD

NOTES:

JOINT DESIGN: B1S.1/MIL. STD. 22

THICK RANGE QUAL.

SKETCH OF WELD LOCATION & TYPICAL PASS SEQUENCE



APPROVALS: J N Nitel   James C Johnston

TODD PACIFIC SHIPYARDS CORPORATION

SEATTLE DIVISION

WELDING PROCEDURE SPECIFICATION

TWPS NO.: D-8

REV:

ISSUED:

PAGE:

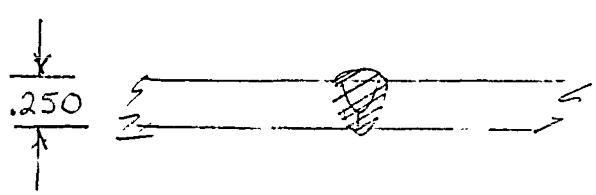
DESCRIPTION	OUT-OF-POSITION, ONE SIDE, FULL PENETRATION MANUAL GAS METAL ARC BUTT WELDING OF ALUMINUM ALLOY SHEETS AND PLATES FOR MARINE APPLICATION		
WELDER QUALIF.	MIL-STD-248C	PROCEDURE QUALIF. STD.	MIL-STD-248C; MIL-STD-278D NAVSHIPS 0900-000-1000/1
BASE METALS	.250" 5086 H116 QQ-A-250/19	PROCESS:	GAS METAL ARC WELDING (GMAW)
SPEC. TYPE FILLER METAL	AWS A5.10-80 ER 5556	POWER SOURCE; MODEL/TYPE	AIRCO PA 350
		POLARITY	DC RP
POSITION OF WELD	VERTICAL-up	FLUX; SPEC/SIZE/TYPE:	NA
		GAS: FLOW RATE/TYPE	40 CFH 75% HE/25% AR
JOINT PREPARATION & SIDE NUMBER	REMOVE SHEAR OR SAW MARKS FROM FAYING SURFACE BY SCRAPING, FILING OR ROUTING BOTH SIDES	TORCH TYPE	BINZEL
		CUP SIZE	3/4INCH ORIFICE
INTERPASS CLEANING	STAINLESS STEEL WIRE BRUSHING		
REPAIRS	REPAIR WELDS SHALL BE MADE TO THE SAME STANDARDS AS THE ORIGINAL WORK		
PREHEAT	AMBIENT	INTERPASS TEMPERATURE	NA
POSTHEAT TEMPERATURE	NA	ELECTRODE CONTROL	TWPS 4003
HEAT TREATMENT	NA		
WELD TECHNIQUE	GMAW STRINGER BEAD		

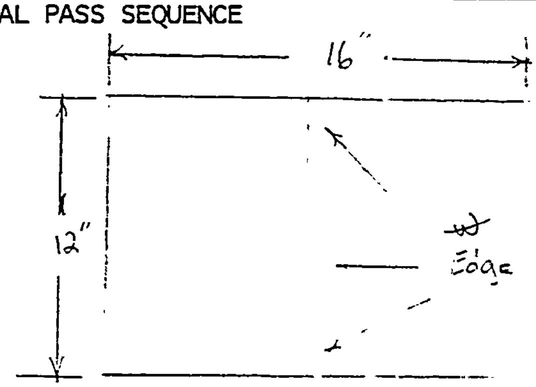
TRAVEL SPEED (I.P.M.)	FILLER METAL SIZE	AMPERAGE RANGE	ARC VOLTAGE RANGE	POSITION
11.5	3/64"	150	16	VERTICAL-UP

NOTES:

JOINT DESIGN: B2U.1/MIL. STD. 22 THICK RANGE QUAL.

SKETCH OF WELD LOCATION & TYPICAL PASS SEQUENCE





APPROVALS: A H Hittel James C Johnston

PACIFIC SHIPYARDS CORPORATION TODD

SEATTLE DIVISION

WELDING PROCEDURE SPECIFICATION

TWPS NO.: D-10

REV:

ISSUED:

PAGE:

DESCRIPTION: OUT-OF POSITION, ONE-SIDE, FULL PENETRATION MANUAL GAS METAL ARC BUTT WELDING OF ALUMINUM ALLOY SHEETS AND PLATES FOR MARINE APPLICATION

WELDER QUALIF.	MIL-STD-248C	PROCEDURE QUALIF. STD.	MIL-STD-248C; MIL-STD-278D NAVSHIPS 0900-000-1000/1
BASE METALS	.250" 5086 H-116 QQ-A250/19	PROCESS:	GAS METAL ARC WELD
SPEC. TYPE FILLER METAL	AWS A5.10-80 ER 5556	POWER SOURCE; MODEL/TYPE	AIRCO PA 350
		POLARITY	DC R P
POSITION OF WELD	HORIZONTAL	FLUX; SPEC/SIZE/TYPE:	NA
		GAS: FLOW RATE/TYPE	100 CFH HELIUM
JOINT PREPARATION & SIDE NUMBER	REMOVE SHEAR OR SAW MARKS FROM FAYING SURFACE BY SCRAPING, FILING, OR ROUTING BOTH SIDES	TORCH TYPE	BINZEL
		CUP SIZE	3/4 INCH ORIFICE
INTERPASS CLEANING	STAINLESS STEEL WIRE BRUSHING		
REPAIRS	REPAIR WELDS SHALL BE MADE TO THE SAME STANDARDS AS THE ORIGINAL WORK		
PREHEAT	AMBIENT	INTERPASS TEMPERATURE	NA
POSTHEAT TEMPERATURE	NA	ELECTRODE CONTROL	TWPS 4003
HEAT TREATMENT	NA		
WELD TECHNIQUE	GMAW STRINGER BEADS		

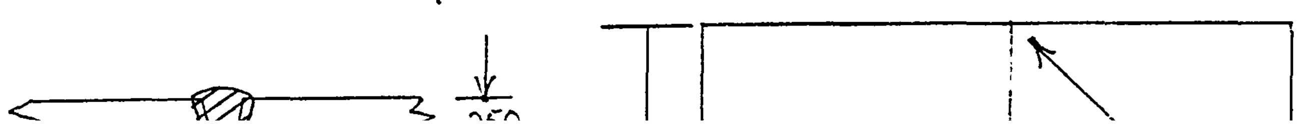
TRAVEL SPEED (I.P.M.)	FILLER METAL SIZE	AMPERAGE RANGE	ARC VOLTAGE RANGE	POSITION
8.4	3/64"	149	14.5	HORIZONTAL

NOTES:

JOINT DESIGN: B2 U.1/MIL. STD. 22

THICK RANGE QUAL.

SKETCH OF WELD LOCATION & TYPICAL PASS SEQUENCE



TODD
PACIFIC SHIPYARDS CORPORATION
SEATTLE DIVISION

WELDING PROCEDURE SPECIFICATION

TWPS NO.: E.7
REV:
ISSUED:
PAGE:

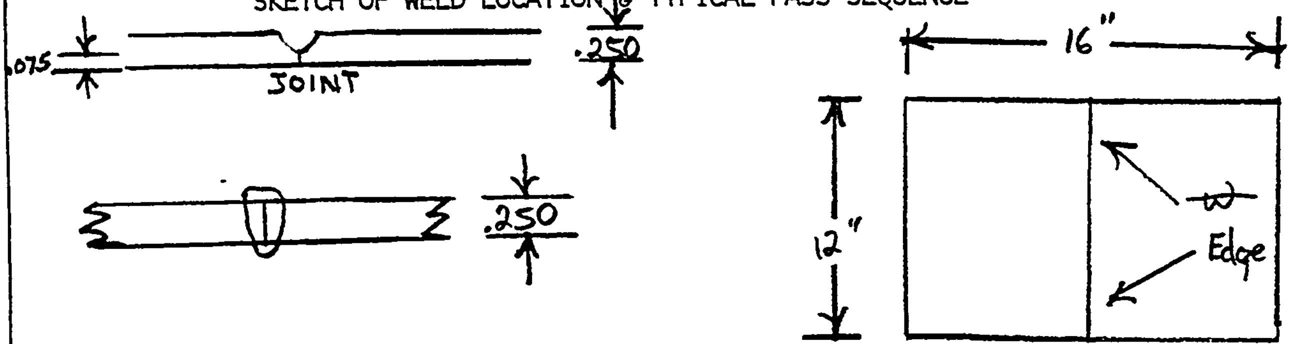
DESCRIPTION	OUT-OF-POSITION, ONE SIDE, FULL PENETRATION MANUAL GAS METAL ARC BUTT WELDING OF ALUMINUM ALLOY SHEETS AND PLATES FOR MARINE APPLICATION		
WELDER QUALIF.	MIL-STD-248C	PROCEDURE QUALIF.STD.	MIL-STD-248C;MIL-STD-278D NAVSHIPS 0900-000-1000/1
BASE METALS	0.250" 5456 H116 QQ-A-250/19	PROCESS:	(GMAW) GAS METAL ARC WELDING SHORT ARC
SPEC. TYPE FILLER METAL	AWS A5.10-80 ER5556	POWER SOURCE;MODEL/TYPE	AIRCO PULSE ARC 350
		POLARITY	DC RP
POSITION OF WELD	VERTICAL UP	FLUX;SPEC/SIZE/TYPE:	NA
		GAS: FLOW RATE/TYPE	40 CFH 75%HE/25%AR
JOINT PREPARATION & SIDE NUMBER	REMOVE SHEAR OR SAW MARKS FROM FAYING SURFACE BY SCRAPING FILING OR ROUTING BOTH SIDES	TORCH TYPE	BINZEL
		CUP SIZE	3/4 INCH ORIFICE
INTERPASS CLEANING	STAINLESS STEEL WIRE BRUSHING		
REPAIRS	REPAIR WELDS SHALL BE MADE TO THE SAME STANDARDS AS THE ORIGINAL WORK		
PREHEAT	AMBIENT	INTERPASS TEMPERATURE	NA
POSTHEAT TEMPERATURE	NA	ELECTRODE CONTROL	TWPS 4003
HEAT TREATMENT	NA		
WELD TECHNIQUE	GMAW STRINGER BEAD		

TRAVEL SPEED (I.P.M.)	FILLER METAL SIZE	AMPERAGE RANGE	ARC VOLTAGE RANGE	POSITION
9.3	3/64"	115	18	VERTICAL-UP

NOTES:

JOINT DESIGN: B2U.1/MIL.STD. 22 THICK RANGE QUAL.

SKETCH OF WELD LOCATION & TYPICAL PASS SEQUENCE



APPROVALS: [signature] [signature]

PACIFIC SHIPYARDS CORPORATION TODD

SEATTLE DIVISION

WELDING PROCEDURE SPECIFICATION

TWPS NO.: E-33
REV:
ISSUED:
PAGE:

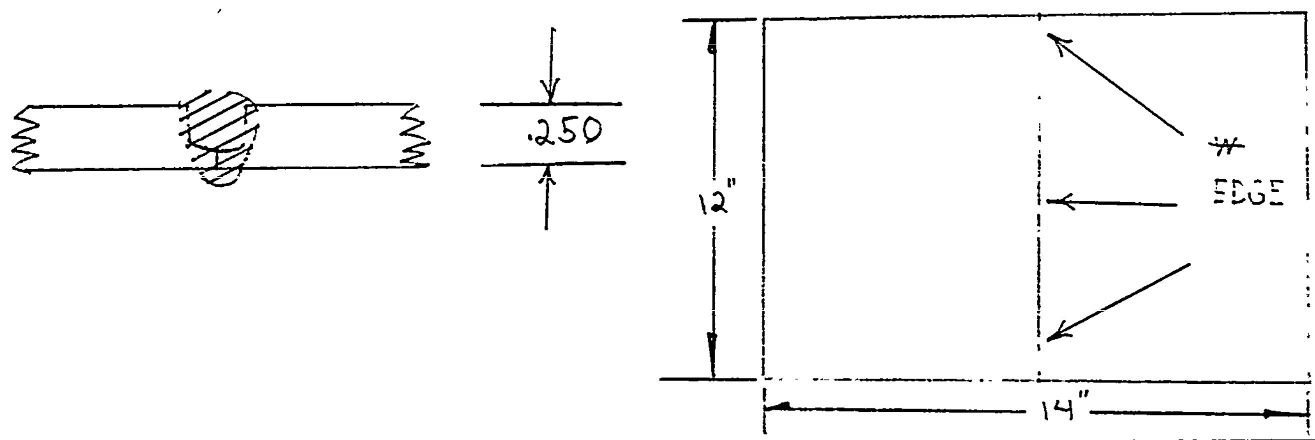
DESCRIPTION	OUT-OF-POSITION, ONE-SIDE, FULL PENETRATION MANUAL GAS METAL ARC BUTT WELDING OF ALUMINUM ALLOY SHEETS AND PLATES FOR MARINE APPLICATION		
WELDER QUALIF.	MIL-STD-248C	PROCEDURE QUALIF. STD.	MIL-STD-248C; MIL-STD-278D NAVSHIPS 0900-000-1000/1
BASE METALS	.250" 5456 H-116 QQ-A250/19	PROCESS:	GAS METAL ARC WELDING
SPEC. TYPE FILLER METAL	AWS A5.10-80 ER 5556	POWER SOURCE; MODEL/TYPE	AIRCO PA 350
		POLARITY	DC RP
POSITION OF WELD	HORIZONTAL	FLUX; SPEC/SIZE/TYPE:	NA
		GAS: FLOW RATE/TYPE	100 CFH HELIUM
JOINT PREPARATION & SIDE NUMBER	REMOVE SHEAR OR SAW MARKS FROM FAYING SURFACE BY SCRAPING, FILING, OR ROUTING BOTH SIDES	TORCH TYPE	BINZEL
		CUP SIZE	3/4 INCH ORIFICE
INTERPASS CLEANING	STAINLESS STEEL WIRE BRUSHING		
REPAIRS	REPAIR WELDS SHALL BE MADE TO THE SAME STANDARDS AS THE ORIGINAL WORK		
PREHEAT	AMBIENT	INTERPASS TEMPERATURE	NA
POSTHEAT TEMPERATURE	NA	ELECTRODE CONTROL	TWPS 4003
HEAT TREATMENT	NA		
WELD TECHNIQUE	GMAW STRINGER BEADS		

TRAVEL SPEED (I.P.M.)	FILLER METAL SIZE	AMPERAGE RANGE	ARC VOLTAGE RANGE	POSITION
8.9	3/64"	156	14.5	HORIZONTAL

NOTES:

JOINT DESIGN: B2 U.1/MIL. STD. 22 THICK RANGE QUAL.

SKETCH OF WELD LOCATION & TYPICAL PASS SEQUENCE



APPROVALS: A H Hitch James C Johnston

WE001

PACIFIC SHIPYARDS CORPORATION — TODD SEATTLE DIVISION	WELDING PROCEDURE SPECIFICATION	TWPS NO.: F-3 REV: ISSUED: PAGE:

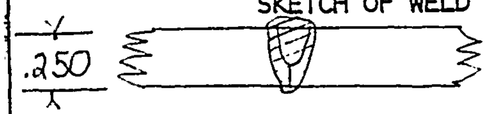
DESCRIPTION	OUT-OF-POSITION, ONE SIDE, FULL PENETRATION MANUAL GAS METAL ARC BUTT WELDING OF ALUMINUM ALLOY SHEETS AND PLATES FOR MARINE APPLICATION		
WELDER QUALIF.	MIL-STD-248C	PROCEDURE QUALIF. STD.	MIL-STD-248C;MIL-STD-278D NAVSHIPS 0900-000-1000/1
BASE METALS	.250" 5083 H321 QQ-H-250/6	PROCESS:	GAS METAL ARC WELDING (GMAW)
SPEC. TYPE FILLER METAL	AWS A5.10-80 ER 5556	POWER SOURCE;MODEL/TYPE	AIRCO PULSE ARC 350
		POLARITY	DC RP
POSITION OF WELD	VERTICAL-UP	FLUX;SPEC/SIZE/TYPE:	NA
		GAS: FLOW RATE/TYPE	40 CFH 75% HE/25% AR
JOINT PREPARATION & SIDE NUMBER	REMOVE SHEAR OR SAW MARKS FROM FAYING SURFACE BY SCRAPING, FILING OR ROUTING BOTH SIDES	TORCH TYPE	BINZEL
		CUP SIZE	3/4 INCH ORIFICE
INTERPASS CLEANING	STAINLESS STEEL WIRE BRUSHING		
REPAIRS	REPAIR WELDS SHALL BE MADE TO THE SAME STANDARDS AS THE ORIGINAL WORK		
PREHEAT	AMBIENT	INTERPASS TEMPERATURE	NA
POSTHEAT TEMPERATURE	NA	ELECTRODE CONTROL	TWPS 4003
HEAT TREATMENT	NA		
WELD TECHNIQUE	GMAW STRINGER BEAD		

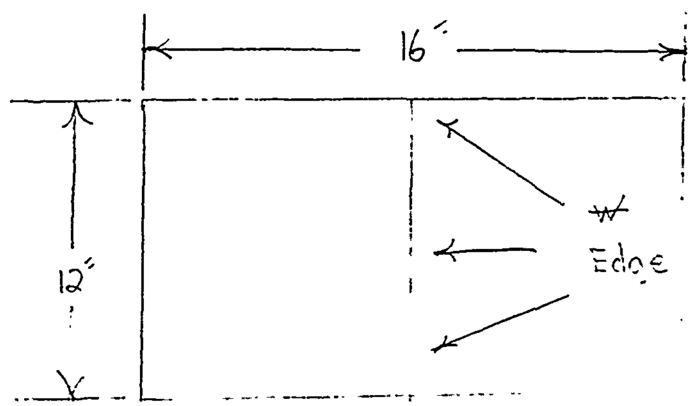
TRAVEL SPEED (I.P.M.)	FILLER METAL SIZE	AMPERAGE RANGE	ARC VOLTAGE RANGE	POSITION
12	3/64"	130	15.7	VERTICAL-UP

NOTES:

JOINT DESIGN: B2U.1/MIL. STD. 22 THICK RANGE QUAL.

SKETCH OF WELD LOCATION & TYPICAL PASS SEQUENCE





APPROVALS: J H Hitil   James C Johnston

WE001

PACIFIC SHIPYARDS CORPORATION

TODD

SEATTLE DIVISION

WELDING PROCEDURE SPECIFICATION

TWPS NO.: F-13

REV:

ISSUED:

PAGE:

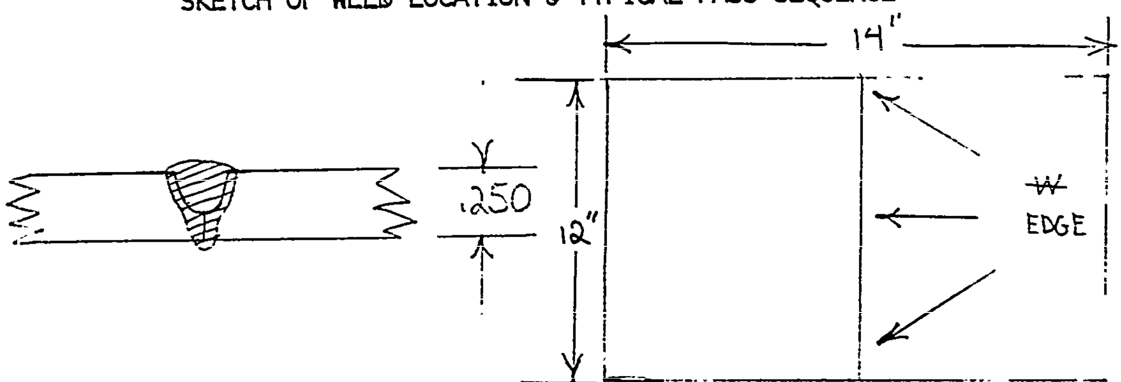
DESCRIPTION	OUT-OF-POSITION, ONE-SIDE, FULL PENETRATION MANUAL GAS METAL ARC BUTT WELDING OF ALUMINUM ALLOY SHEETS AND PLATES FOR MARINE APPLICATION		
WELDER QUALIF.	MIL-STD-248C	PROCEDURE QUALIF.STD.	MIL-STD-248C; MIL-STD-278D NAVSHIPS 0900-000-1000/1
BASE METALS	.250" 5083 H-321 QQ-A250/6	PROCESS:	GAS METAL ARC WELDING
SPEC. TYPE FILLER METAL	AWS A5.10-80 ER 5556	POWER SOURCE; MODEL/TYPE	AIRCO PA 350
		POLARITY	DC RP
POSITION OF WELD	HORIZONTAL	FLUX; SPEC/SIZE/TYPE:	NA
		GAS: FLOW RATE/TYPE	100 CFH/ HELIUM
JOINT PREPARATION & SIDE NUMBER	REMOVE SHEAR OR SAW MARKS FROM FAYING SURFACE BY SCRAPING, FILING, OR ROUTING BOTH SIDES	TORCH TYPE	BINZEL
		CUP SIZE	3/4 INCH ORIFICE
INTERPASS CLEANING	STAINLESS STEEL WIRE BRUSHING		
REPAIRS	REPAIR WELDS SHALL BE MADE TO THE SAME STANDARDS AS THE ORIGINAL WORK		
PREHEAT	AMBIENT	INTERPASS TEMPERATURE	NA
POSTHEAT TEMPERATURE	NA	ELECTRODE CONTROL	TWPS 4003
HEAT TREATMENT	NA		
WELD TECHNIQUE	GMAW STRINGER BEADS		

TRAVEL SPEED (I.P.M.)	FILLER METAL SIZE	AMPERAGE RANGE	ARC VOLTAGE RANGE	POSITION
10.2	3/64"	145	14.5	HORIZONTAL

NOTES:

JOINT DESIGN: B2 U.1/MIL. STD. 22 THICK RANGE QUAL.

SKETCH OF WELD LOCATION & TYPICAL PASS SEQUENCE



APPROVALS: [signature] [signature: James C. Johnston]

WF001

PACIFIC SHIPYARDS CORPORATION — TODD

SEATTLE DIVISION

WELDING PROCEDURE SPECIFICATION

TWPS NO.: A1.34
REV:
ISSUED:
PAGE:

DESCRIPTION	MECHANIZED FLAT, ONE-SIDE, FULL PENETRATION GAS METAL ARC BUTT WELDING OF ALUMINUM ALLOY SHEETS AND PLATES FOR MARINE APPLICATION
WELDER QUALIF.	MIL-STD-248C
PROCEDURE QUALIF.STD.	MIL-STD-248C;MIL-STD-278D NAVSHIPS 0900-000-1000/1
BASE METALS	.063" 5086 H-32 QQ-A-250/7
PROCESS:	GAS METAL ARC WELDING (GMAW)
SPEC. TYPE FILLER METAL	AWS A5.10-80 Er 5356
POWER SOURCE;MODEL/TYPE	GILLILAND CV600 FI-PA
POLARITY	DCRP
POSITION OF WELD	FLAT
FLUX;SPEC/SIZE/TYPE:	NA
GAS: FLOW RATE/TYPE	40 CFH
JOINT PREPARATION & SIDE NUMBER	REMOVE SHEAR OR SAW MARKS FROM FAYING SURFACE BY SCRAPING, FILING OR ROUTING BOTH SIDES
TORCH TYPE	MTG 4001
CUP SIZE	3/4 INCH ORIFICE
INTERPASS CLEANING	STAINLESS STEEL WIRE BRUSHING
REPAIRS	REPAIR WELDS SHALL BE MADE TO THE SAME STANDARDS AS THE ORIGINAL WORK
PREHEAT	AMBIENT
INTERPASS TEMPERATURE	NA
POSTHEAT TEMPERATURE	NA
ELECTRODE CONTROL	TWPS 4003
HEAT TREATMENT	NA
WELD TECHNIQUE	GMAW STRINGER BEAD

TRAVEL SPEED (I.P.M.)	FILLER METAL SIZE	AMPERAGE RANGE	ARC VOLTAGE RANGE	POSITION
24.5	3/64"	50	13.5	FLAT

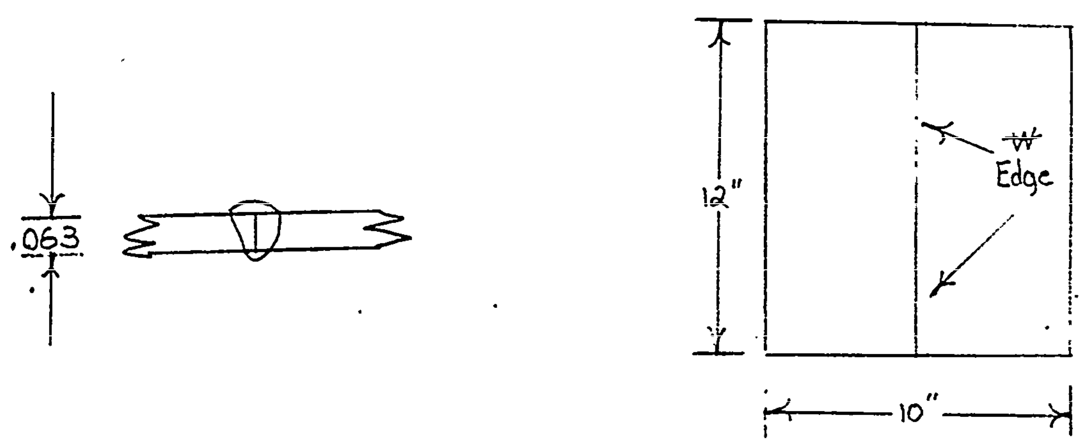
NOTES:

60 PPS
MECHANIZED BUG-O

JOINT DESIGN: B1S.1/MIL. STD. 22

THICK RANGE QUAL.

SKETCH OF WELD LOCATION & TYPICAL PASS SEQUENCE



APPROVALS:

TODD PACIFIC SHIPYARDS CORPORATION

SEATTLE DIVISION

WELDING PROCEDURE SPECIFICATION

TWPS NO.: B.77

REV:

ISSUED:

PAGE:

DESCRIPTION	MECHANIZED FLAT, ONE-SIDE, FULL PENETRATION GAS METAL ARC BUTT WELDING OF ALUMINUM ALLOY SHEETS AND PLATES FOR MARINE APPLICATION
WELDER QUALIF.	MIL-STD-248C
PROCEDURE QUALIF.STD.	MIL-STD-248C;MIL-STD-278D NAVSHIPS 0900-000-1000/1
BASE METALS	.100" 5086 H-32 QQ-A-250/7
PROCESS:	GAS METAL ARC WELDING (GMAW)
SPEC. TYPE FILLER METAL	AWS A5.10-80 ER 5356
POWER SOURCE;MODEL/TYPE	GILLILAND CV600 FI-PA
POLARITY	DCRP
POSITION OF WELD	FLAT
FLUX;SPEC/SIZE/TYPE:	NA
GAS: FLOW RATE/TYPE	40 CFH
TORCH TYPE	MTG 4001
CUP SIZE	3/4 INCH ORIFICE
JOINT PREPARATION & SIDE NUMBER	REMOVE SHEAR OR SAW MARKS FROM FAYING SURFACE BY SCRAPING, FILING OR ROUTING BOTH SIDES
INTERPASS CLEANING	STAINLESS STEEL WIRE BRUSHING
REPAIRS	REPAIR WELDS SHALL BE MADE TO THE SAME STANDARDS AS THE ORIGINAL WORK
PREHEAT	AMBIENT
INTERPASS TEMPERATURE	NA
POSTHEAT TEMPERATURE	NA
ELECTRODE CONTROL	TWPS 4003
HEAT TREATMENT	NA
WELD TECHNIQUE	GMAW STRINGER BEAD

TRAVEL SPEED (I.P.M.)	FILLER METAL SIZE	AMPERAGE RANGE	ARC VOLTAGE RANGE	POSITION
22	3/64"	60	16.5	FLAT

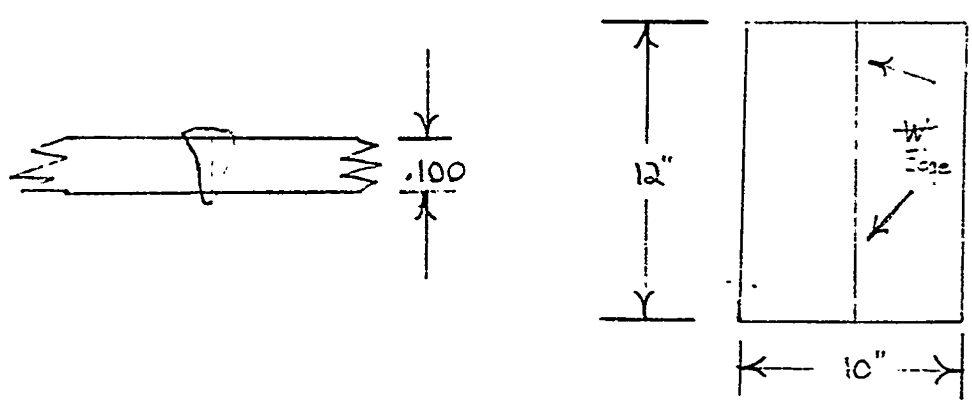
NOTES:

60 PPS
MECHANIZED BUG-O

JOINT DESIGN: B1S.1/MIL. STD. 22

THICK RANGE QUAL.

SKETCH OF WELD LOCATION & TYPICAL PASS SEQUENCE



APPROVALS: [signature] [signature]

PACIFIC SHIPYARDS CORPORATION (TODD)

SEATTLE DIVISION

WELDING PROCEDURE SPECIFICATION

TWPS NO.: C.67, C.65
REV:
ISSUED:
PAGE:

DESCRIPTION: MECHANIZED FLAT, ONE-SIDE, FULL PENETRATION GAS METAL ARC BUTT WELDING OF ALUMINUM ALLOY SHEETS AND PLATES FOR MARINE APPLICATION

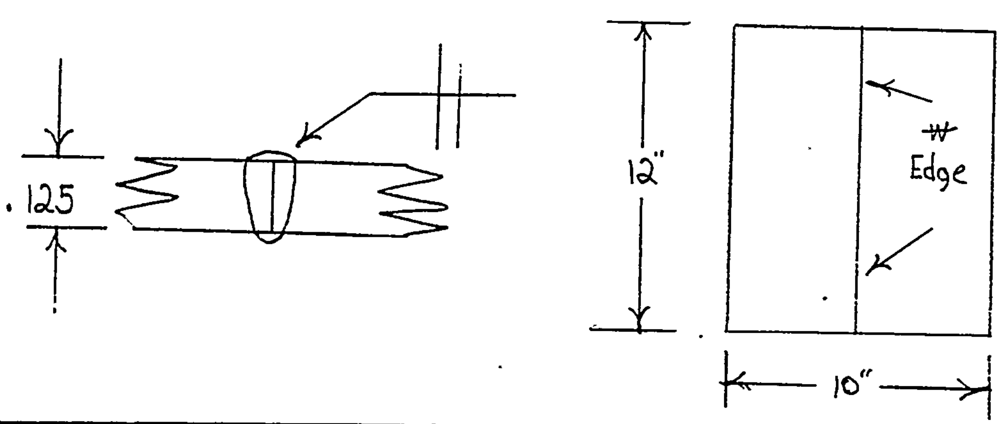
WELDER QUALIF.	MIL-STD-248C	PROCEDURE QUALIF.STD.	MIL-STD-248C;MIL-STD-278D NAVSHIPS 0900-000-1000/1
BASE METALS	.125" 5083-H323	PROCESS:	GAS METAL ARC WELDING (GMAW)
SPEC. TYPE FILLER METAL	AWS A5.10-80 ER 5356	POWER SOURCE;MODEL/TYPE	GILLILAND CV600 FI-PA
		POLARITY	DCRP
POSITION OF WELD	FLAT	FLUX;SPEC/SIZE/TYPE:	NA
		GAS: FLOW RATE/TYPE	40 CFH
JOINT PREPARATION & SIDE NUMBER	REMOVE SHEAR OR SAW MARKS FROM FAYING SURFACE BY SCRAPING, FILING OR ROUTING BOTH SIDES	TORCH TYPE	MTG 4001
		CUP SIZE	3/4 INCH ORIFICE
INTERPASS CLEANING	STAINLESS STEEL WIRE BRUSHING		
REPAIRS	REPAIR WELDS SHALL BE MADE TO THE SAME STANDARDS AS THE ORIGINAL WORK		
PREHEAT	AMBIENT	INTERPASS TEMPERATURE	NA
POSTHEAT TEMPERATURE	NA	ELECTRODE CONTROL	TWPS 4003
HEAT TREATMENT	NA		
WELD TECHNIQUE	GMAW STRINGER BEAD		

TRAVEL SPEED (I.P.M.)	FILLER METAL SIZE	AMPERAGE RANGE	ARC VOLTAGE RANGE	POSITION
16.2	3/64"	68	18.6	FLAT

NOTES:
60 PPS
MECHANIZED BUG-O

JOINT DESIGN: B1S.1/MIL. STD. 22 THICK RANGE QUAL.

SKETCH OF WELD LOCATION & TYPICAL PASS SEQUENCE



APPROVALS: [signatures]

PACIFIC SHIPYARDS CORPORATION (TODD) SEATTLE DIVISION	WELDING PROCEDURE SPECIFICATION	TWPS NO.: C.68, C.69, C.70
		REV:
		ISSUED:
		PAGE:

DESCRIPTION	MECHANIZED FLAT, ONE-SIDE, FULL PENETRATION GAS METAL ARC BUTT WELDING OF ALUMINUM ALLOY SHEETS AND PLATES FOR MARINE APPLICATION
WELDER QUALIF.	MIL-STD-248C
PROCEDURE QUALIF. STD.	MIL-STD-248C; MIL-STD-278D NAVSHIPS 0900-000-1000/1
BASE METALS	.125" 5083 H-323 QQ-A-250/6
PROCESS:	PULSE GAS METAL ARC WELDING (GMAW)
SPEC. TYPE FILLER METAL	AWS A5.10-80
POWER SOURCE; MODEL/TYPE	MILLER PULSTAR 450
POLARITY	DCRP
POSITION OF WELD	FLAT
FLUX; SPEC/SIZE/TYPE:	NA
GAS: FLOW RATE/TYPE	40 CFH 75%HE/25%AR
JOINT PREPARATION & SIDE NUMBER	REMOVE SHEAR OR SAW MARKS FROM FAYING SURFACE BY SCRAPING, FILING OR ROUTING BOTH SIDES
TORCH TYPE	AH 35 C-2
CUP SIZE	3/4 INCH ORIFICE
INTERPASS CLEANING	STAINLESS STEEL WIRE BRUSHING
REPAIRS	REPAIR WELDS SHALL BE MADE TO THE SAME STANDARDS AS THE ORIGINAL WORK
PREHEAT	AMBIENT
INTERPASS TEMPERATURE	NA
POSTHEAT TEMPERATURE	NA
ELECTRODE CONTROL	TWPS 4003
HEAT TREATMENT	NA
WELD TECHNIQUE	GMAW STRINGER BEAD

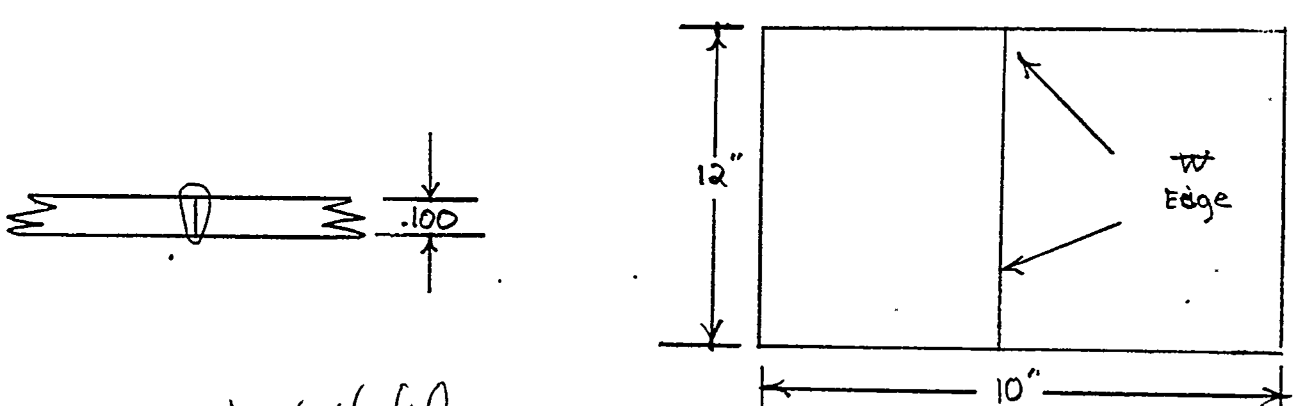
TRAVEL SPEED (I.P.M.)	FILLER METAL SIZE	AMPERAGE RANGE	ARC VOLTAGE RANGE	POSITION
16.1	3/64"	70	21.2	FLAT

NOTES:

60 PPS
MECHANIZED BUG-O

JOINT DESIGN: B1S.1/MIL. STD. 22 THICK RANGE QUAL.

SKETCH OF WELD LOCATION & TYPICAL PASS SEQUENCE



APPROVALS: [signature] [signature: James C Johnston]

PACIFIC SHIPYARDS CORPORATION

SEATTLE DIVISION

WELDING PROCEDURE SPECIFICATION

TWPS NO.: D-25
REV:
ISSUED:
PAGE:

DESCRIPTION
MECHANIZED FLAT ONE-SIDE, FULL PENETRATION GAS METAL ARC BUTT WELDING OF ALUMINUM ALLOY SHEETS AND PLATES FOR MARINE APPLICATION

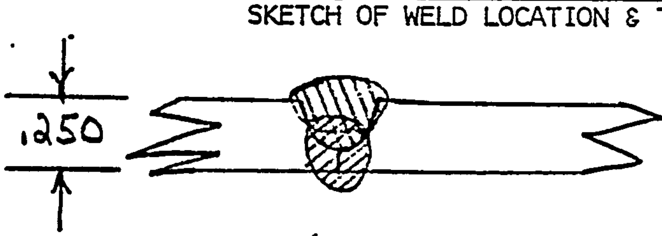
WELDER QUALIF.	MIL-STD-248C	PROCEDURE QUALIF.STD.	MIL-STD-248C;MIL-STD-278D NAVSHIPS 0900-000-1000/1
BASE METALS	.250" 5086 H-116 QQ-A-250/19	PROCESS:	PULSE GAS METAL ARC WELDING
SPEC. TYPE FILLER METAL	AWS A5.10-80 ER 5556	POWER SOURCE;MODEL/TYPE	MILLER PULSTAR 450
		POLARITY	DCRP
POSITION OF WELD	FLAT MECHANIZED	FLUX;SPEC/SIZE/TYPE:	NA
		GAS: FLOW RATE/TYPE	40 CFH 75%HE/25%AR
JOINT PREPARATION & SIDE NUMBER	REMOVE SHEAR OR SAW MARKS FROM FAYING SURFACE BY SCRAPING, FILING OR ROUTING BOTH SIDES	TORCH TYPE	AIRCO AH 35-C2
		CUP SIZE	3/4" ORIFICE
INTERPASS CLEANING	STAINLESS STEEL WIRE BRUSHING		
REPAIRS	REPAIR WELDS SHALL BE MADE TO THE SAME STANDARDS AS THE ORIGINAL WORK		
PREHEAT	AMBIENT	INTERPASS TEMPERATURE	AMBIENT
POSTHEAT TEMPERATURE	NA	ELECTRODE CONTROL	TWPS 4003
HEAT TREATMENT	NA		
WELD TECHNIQUE	GMAW STRINGER BEADS		

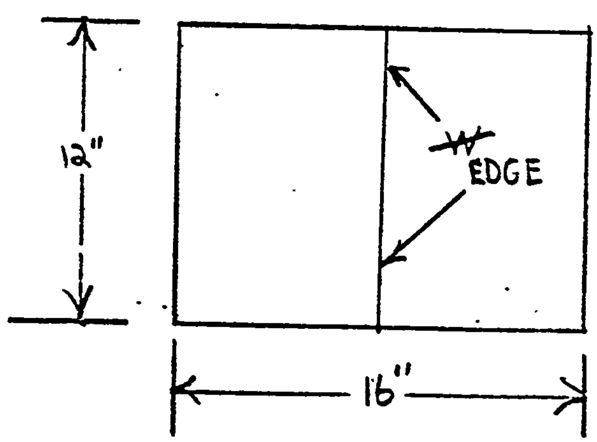
TRAVEL SPEED (I.P.M.)	FILLER METAL SIZE	AMPERAGE RANGE	ARC VOLTAGE RANGE	POSITION
16	3/64"	105	23	FLAT
12.2	3/64"	105	24	FLAT

NOTES:
120 PPS
MECHANIZED BUG-O

JOINT DESIGN: B2U.1/MIL.STD. 22 THICK RANGE QUAL.

SKETCH OF WELD LOCATION & TYPICAL PASS SEQUENCE





APPROVALS: [signature] [signature]

PACIFIC SHIPYARDS CORPORATION

SEATTLE DIVISION

WELDING PROCEDURE SPECIFICATION

TWPS NO.: D-28
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DESCRIPTION	MECHANIZED FLAT, ONE-SIDE, FULL PENETRATION GAS METAL ARC BUTT WELDING OF ALUMINUM ALLOY SHEETS AND PLATES FOR MARINE APPLICATION		
WELDER QUALIF.	MIL-STD-248C	PROCEDURE QUALIF.STD.	MIL-STD-248C;MIL-STD-278D NAVSHIPS 0900-000-1000/1
BASE METALS	.250" 5086 H-116 QQ-A-250/19	PROCESS:	PULSE GAS METAL ARC WELDING
SPEC. TYPE FILLER METAL	AWS A5.10-80 ER 5356	POWER SOURCE;MODEL/TYPE	AIRCO PA 350
		POLARITY	DCRP
POSITION OF WELD	FLAT MECHANIZED	FLUX;SPEC/SIZE/TYPE:	NA
		GAS: FLOW RATE/TYPE	40 CFH 75%HE/25%AR
JOINT PREPARATION & SIDE NUMBER	REMOVE SHEAR OR SAW MARKS FROM FAYING SURFACE BY SCRAPING, FILING OR ROUTING BOTH SIDES	TORCH TYPE	BINZEL
		CUP SIZE	3/4" ORIFICE
INTERPASS CLEANING	STAINLESS STEEL WIRE BRUSHING		
REPAIRS	REPAIR WELDS SHALL BE MADE TO THE SAME STANDARDS AS THE ORIGINAL WORK		
PREHEAT	AMBIENT	INTERPASS TEMPERATURE	AMBIENT
POSTHEAT TEMPERATURE	NA	ELECTRODE CONTROL	TWPS 4003
HEAT TREATMENT	NA		
WELD TECHNIQUE	STRINGER BEADS		

TRAVEL SPEED (I.P.M.)	FILLER METAL SIZE	AMPERAGE RANGE	ARC VOLTAGE RANGE	POSITION
12.2	3/64"	92	24.8	FLAT
16	3/64"	124	26.5	FLAT

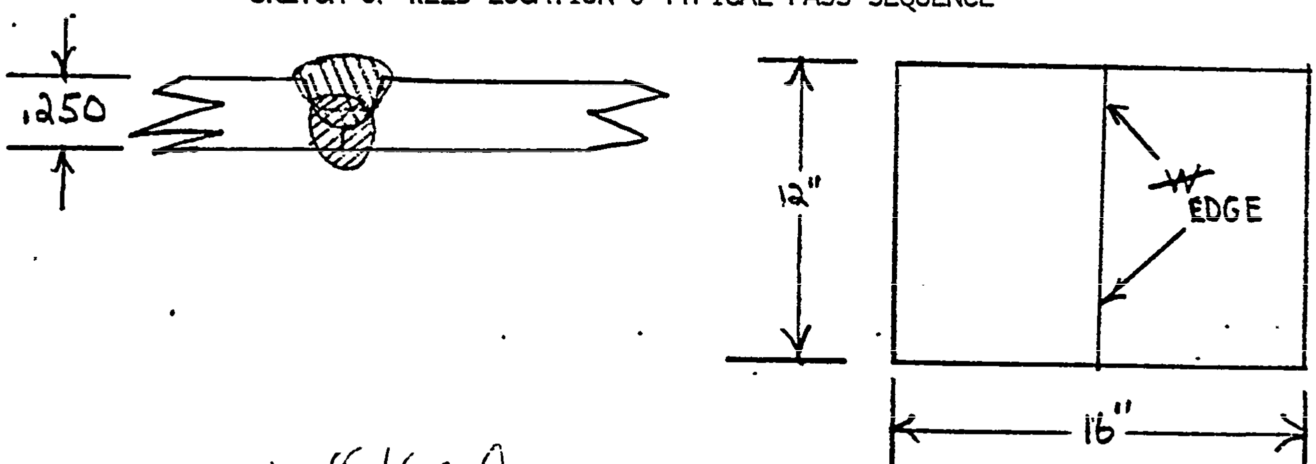
NOTES:

MECHANIZED BUG-O

ELECTRONICALLY PROGRAMMED WIRE FEED

JOINT DESIGN: B2U.1/ MIL.STD. 22 THICK RANGE QUAL.

SKETCH OF WELD LOCATION & TYPICAL PASS SEQUENCE



APPROVALS:

PACIFIC SHIPYARDS CORPORATION
TODD
SEATTLE DIVISION

WELDING PROCEDURE SPECIFICATION

TWPS NO.: I-10
REV:
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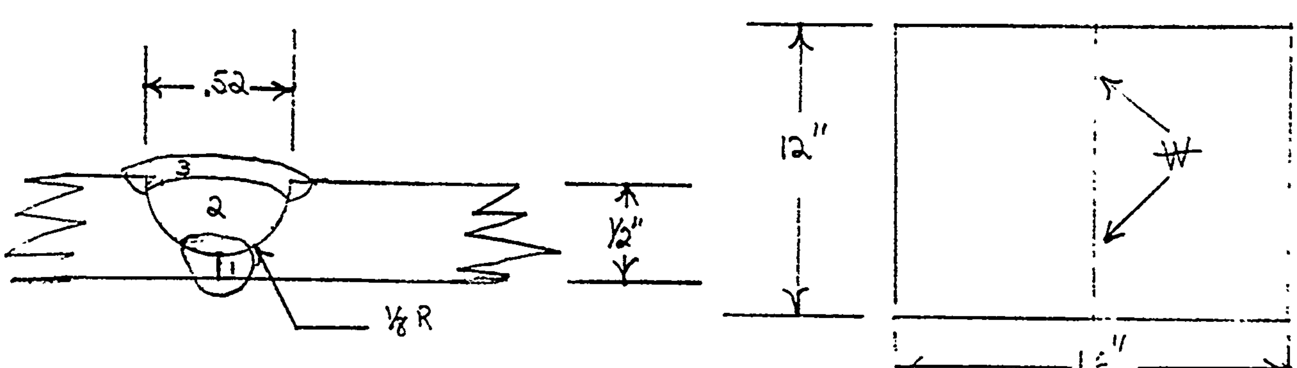
DESCRIPTION	MECHANIZED FLAT, ONE-SIDE, FULL PENETRATION GAS METAL ARC BUTT WELDING OF ALUMINUM ALLOY SHEETS AND PLATES FOR MARINE APPLICATION
WELDER QUALIF.	MIL-STD-248C
PROCEDURE QUALIF.STD.	MIL-STD-248C;MIL-STD-278D NAVSHIPS 0900-000-1000/1
BASE METALS	.500 INCH 5083-H321 QQ-A-250/6
PROCESS:	PULSE GAS METAL ARC WELDING
SPEC. TYPE FILLER METAL	AWS A5.10-80 ER 5356
POWER SOURCE;MODEL/TYPE	MILLER PULSTAR 450
POLARITY	DCRP
POSITION OF WELD	FLAT
FLUX;SPEC/SIZE/TYPE:	NA
GAS: FLOW RATE/TYPE	40 CFH 75%HE/25%AR
TORCH TYPE	AH 35-C2
CUP SIZE	3/4 INCH ORIFICE
JOINT PREPARATION & SIDE NUMBER	REMOVE SHEAR OR SAW MARKS FROM FAYING SURFACE BY SCRAPING, FILING OR ROUTING BOTH SIDES
INTERPASS CLEANING	STAINLESS STEEL WIRE BRUSHING
REPAIRS	REPAIR WELDS SHALL BE MADE TO THE SAME STANDARDS AS THE ORIGINAL WORK
PREHEAT	AMBIENT
INTERPASS TEMPERATURE	AMBIENT
POSTHEAT TEMPERATURE	NA
ELECTRODE CONTROL	TWPS 4003 NA
HEAT TREATMENT	NA
WELD TECHNIQUE	GMAW STRINGER BEAD

TRAVEL SPEED (I.P.M.)	FILLER METAL SIZE	AMPERAGE RANGE	ARC VOLTAGE RANGE	POSITION
14	3/64"	150	25	FLAT
11.5	3/64"	160	28	FLAT
11.5	3/64"	157	28	FLAT

NOTES: 120 pps
MECHANIZED BUG-O

JOINT DESIGN: B2U.1/MIL. STD. 22 THICK RANGE QUAL.

SKETCH OF WELD LOCATION & TYPICAL PASS SEQUENCE



APPROVALS: J H Hittle James C Johnston

GENERAL CONCLUSIONS AND RECOMMENDATIONS

General conclusions and recommendations that were generated from the analysis of the test results of this program are listed as follows:

1. All four pulse gas metal arc welding power sources were capable of making out-of-position, one-side, full penetration, manual pulse gas metal arc butt welds in 5000 series aluminum alloy sheet and plate for marine structure applications.

2. Pulsed gas metal arc welding power sources, wire feed systems and two position manual GMAW torches are available at prices comparable to conventional gas metal arc welding systems.

3. Single knob adjustments of pulse peak voltage, pulse background and induction have eliminated the element of complexity in setting the welding parameters.

4. With the advent of newer pulse welding machines, it is anticipated that more and more manual pulse spray and “pulse short-circuiting” arc welding of 5000 series aluminum alloy sheet and plates for fabrication of marine structures will take place.

5. Pulsed spray and “pulsed short-circuiting” gas metal arc welding processes and techniques are keys to preventing weld distortions and handling out-of-position joining of marine aluminum alloy sheet and plates.